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An

ENGINEERING REVIEW

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The Use of Sewage for Irrigation after Treatment in Septic Tanks in Tropical Countries.

THE disposal of sewage, or the waste products of human and animal life, is becoming in all countries one of the most pressing questions of the present time, owing to the rapid increase in the population and consequent congestion entailed. The disposal of the sullage of large towns is a matter of the utmost importance and difficulty, and on it rests the health of the community. Each case must be treated separately and in a special manner, owing to the varying local conditions, due to the various situations and natural environments of the towns.

In tropical countries all the difficulties inherent in dealing with sewage questions are accentuated. The monsoon rainfall, extending over a very limited period, is followed by the cold weather or winter season, with a small and almost inappreciable fall, and is in turn succeeded by the hot weather, with none.

It will be at once apparent that the sewage water to be dealt with is greatest during the monsoon rains, when the earth is soaked with moisture and the land requires no irrigation; while in the hot weather everything is dried up and parched by the heat; but at this season the sewage is least in volume, though greatest in strength.

Again, during the cold weather, when the sullage supply is still large, very little is required for cultivation. owing to the heavy tropical dews during this season.

In spite of these drawbacks, sewage water can be used to very great advantage for irrigation, and the excess quantity not required for the land can be so purified as to permit its being discharged into rivers or streams without contaminating them.

This article deals only with small schemes, suitable for medium-sized municipal towns and small communities, such as jails, hospitals and similar institutions, and an attempt has been made to show how the sewage from such sources can be turned to profit, instead of being, as is now too often the case, a source of expense and in many instances a public nuisance.

The economic disposal of sewage for small towns is much the same in all countries, but in the tropics the difference between good and bad treatment is accentuated owing to the extreme climatic conditions, which define the seasons more exactly than in the case of temperate zones.

The sewage of manufacturing towns is often contaminated by waste products being discharged into the sewers in such quantities as to render it unfit for use for irrigation. These waste products may contain so large an excess of acid or

alkali as to affect the whole sullage, but in the case of domestic sewage there is but little variation. The constituents of an average domestic sewage in the temperate zone are :—

In Solution.

Solids	50·54
Organic carbon	3·28
,, nitrogen	1·54
Ammonia	4·70
Chlorine	7·46

Suspended.

Mineral	16·92
Organic	14·36

In the tropics the following is a fair average of crude sewage :—

Total solids	48
Suspended do.	22
Chlorine	3·5
Free ammonia	1·0
Albuminoid ammonia ...	1·0

The nitrites and nitrates are practically nil, and the sewage varies much during different hours of the day, being strongest in the mornings and evenings and weakest during the middle of the day and night.

The free dilution of the sullage with water from the washing places, usually attached to all institutions in the tropics, tends to reduce the proportion of suspended to total solids, as a general rule, to about two to one.

From small installations the mineral solids are practically nil, and it is only in town sewage, where road washings are discharged through the sewers, that any appreciable amount of mineral solids are to be expected.

In India, practically the whole of the animal dung, which should be available to manure the land, is used for making fuel by mixing it with straw, grass, leaves and vegetable refuse. The sewage therefore consists almost entirely of human excreta, which, as a rule, is wasted by being deposited in out-of-the-way places, usually in large clumps of prickly pear, which form the public latrines of most towns, and are a public nuisance.

By the establishment of suitable latrines with a copious supply of water coupled with a installation of septic tanks, the nuisance could be converted into a source of profit to the community.

Sewage may be applied to the land either in a crude or purified state.

Crude sewage is difficult to use owing to the suspended solid matter and the offensive smell given off under a hot sun.

Land which could not possibly be irrigated with crude sewage can be profitably cultivated with the effluent from septic tanks. For crude sewage, a sandy and porous soil is imperative, to allow of rapid ensoakage ; while with the effluent from septic tanks, loam, heavy and even clay soils can be irrigated without any offensive odour.

The effluent from septic tanks, though having no smell and being nearly innoxious, is still hardly pure enough to discharge into streams or rivers unless there is a comparatively large volume of flowing water to dilute it.

The effluent can, however, be further purified by passing it through aërobic filters of coal, brick, or broken stone, so that during the rainy season, when irrigation is not required, the purified sullage can be discharged into the rivers without contaminating them.

An aërobic filter is always a useful appendage to a septic tank, as although, generally, the flow in the streams would be sufficient to dilute the effluent from the tank, there are sometimes periods of short rainfall, when the discharge of the stream (which in tropical countries rapidly diminishes as soon as the rain ceases) would hardly be enough to dilute the effluent ; while, owing to cloudy weather and small evaporation, it might be inadvisable to turn it into the land.

The chief characteristic of sewage irrigation is luxuriant plant growth, the crops being exceedingly heavy and succulent. With crude sewage the sullage water can only be applied to the land by furrow irrigation, between the lines of plants ; but with the effluent from septic tanks, flooding by check levees, or any other means of applying the water generally followed in ordinary irrigation can be practised, the only difference being that the effluent contains dissolved fertilising agents.

Moreover, there is no deposit of slime on the surface of the land, which is one

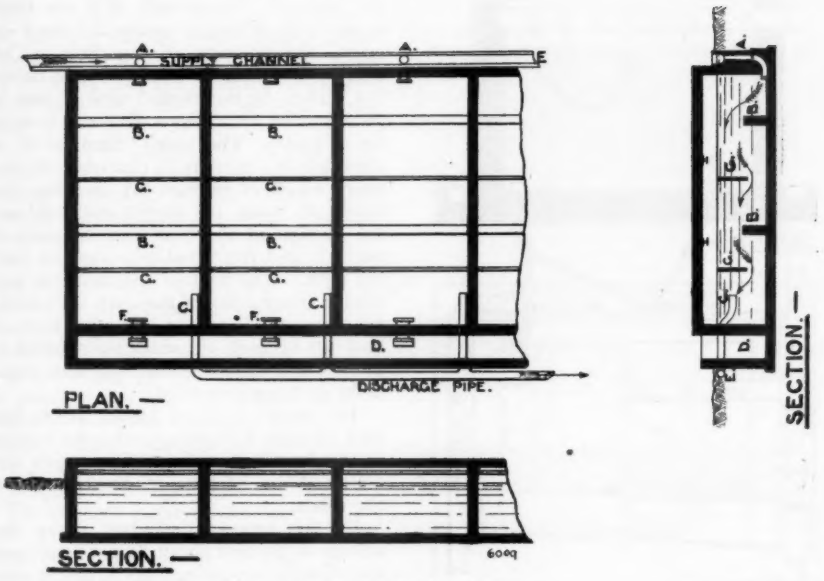


FIG. 1.—DETAILS OF SEPTIC TANK.

of the greatest drawbacks to the use of crude sewage.

The fertilising properties of the sewage are rather increased than diminished by purification in septic tanks.

In the same way, there is no loss of fertilising power by further purifying the effluent from septic tanks by passing it through aërobic filters; the crops grown from the purified effluent being about 20 per cent. better than those grown from the sewage treated only by septic tanks.

Septic tanks for the purification of sewage are essentially simple in design, construction, and use, and consist of one or more rectangular compartments with masonry side walls, in which the sewage is collected and through which it flows at a velocity of about 20 ft. per hr. In other words, the sewage remains in the tanks for from 8 hrs. to 10 hrs., a continual flow being maintained by gradually drawing off the effluent at one end as the crude sewage enters at the other.

In order to prevent a too rapid and direct flow from inlet to outlet, obstructions are placed in the path of the current, so as to cause a slight up-and-down motion in the contents of the tank as the sewage passes through it.

These obstructions are usually low cross-walls on the bed of the tank, and planks of wood near the surface.

The purification of the sewage is effected by the action of myriads of bacteria, which attack the solid matter, converting it into liquids and gases. The soluble gases are dissolved and absorbed by the water in the sullage, while the insoluble escape from the surface.

A scum, 1 in. to 3 ins. in thickness, forms on the surface of the tanks, through which the gases escape in bubbles. These gases are inflammable, and a sheet of flame over the surface of the scum can be obtained by igniting them.

The gases given off consist chiefly of carbonic acid (CO_2), hydrogen, nitrogen, and marsh gas (CH_4). The action of a septic tank, followed by the treatment of the effluent in an aërobic filter, results in the breaking down of all solid matter,

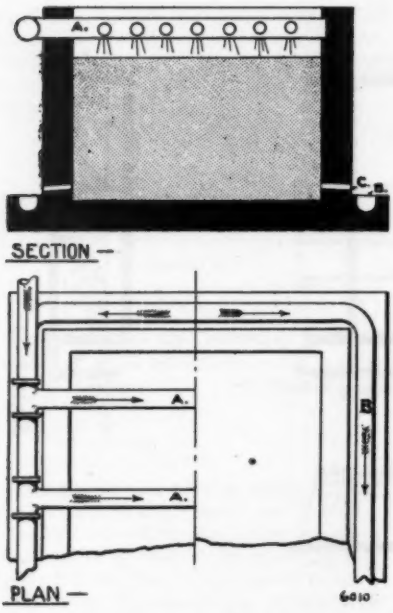


FIG. 2.—DETAILS OF AEROBIC FILTER.

great reduction in the amount of free albuminoid ammonia, coupled with the production of nitrites and nitrates, while the amount of chlorine remains practically unaltered.

The action is quite automatic, no attendance is required, nor is there any recurring expense, except the occasional cleaning of the filter, say once a year. It is advisable to cover in all septic tanks, as the rain, beating on the scum, disturbs the surface and interferes with the action of the bacteria, resulting in a less pure effluent. Practically all the solids are broken down and dissolved or given off in the form of gas, but there is a small quantity of insoluble matter, which is deposited on the floor of the tank, amounting in a year to from 6 ins. to a foot in depth, which should be cleared out at intervals.

Plan and sections of a septic tank are shown in Fig. 1. The crude sewage enters near the bottom of the tank through the pipes *A*. Cross walls *B B* are built about 2 ft. in height across the tank to arrest the velocity of the flow. The effluent is taken off about 18 ins. below the surface by the slotted pipe *C*, and is conveyed by the channel *E* to the land to be irrigated. The small chamber *D* is used for the periodical cleansing of the tank, which is effected by opening the valves *F*, when the sludge collected on the bottom of the tank can be washed through and deposited in a cess-pit near the tank. The roof of the tanks is preferably constructed of masonry arch-work, but corrugated iron or any other form of roof can be used, the main point being to protect the surface scum from any possibility of being disturbed.

The planks *G G* are placed across the tank to cause a slight up-and-down motion in the flowing sewage, as this assists the action of the bacteria in breaking down the solids.

By the process described above the sewage is purified about 80 per cent., and the effluent, possessing high fertilising properties, is fit for immediate application to the land for irrigation, and is practically inodorous. In arid countries about 4,000 gals. per day are required for each acre of land to be irrigated, but good porous or sandy soil will absorb double this quantity with advantage, especially during the hot weather. A floor area of 2,200 sq. ft. in the tank should be provided for each acre to be irrigated, with tanks in which the depth of sewage is four feet.

It is advisable to construct the tanks in compartments of 20 ft. by 10 ft., as each tank will then represent one acre of irrigation, and the installation can be gradually increased, as the volume of sewage grows larger, by simply adding to the number of tanks, without disturbing the general arrangement of the scheme.

One hundred persons will generally provide sufficient sewage for the irrigation of an acre; but a much larger quantity of purified sullage can be used, if the area available for cultivation is limited.

It is always better to use too little effluent than too much, as, although the land may be able to absorb a larger amount than that actually required by

the crops, it may in time, become water-logged. The best results can be obtained by applying only the quantity of effluent required for the full development of the crop.

As already stated, the effluent from septic tanks can be further purified by passing it through aërobic filters, which in their simplest form are small chambers of masonry about 3 ft. in depth filled with coke, coal or broken brick, on to which the effluent from the septic tanks is allowed to drip from perforated pipes, as illustrated in Fig. 2. The crude sewage having been purified about 80 per cent. by its passage through the septic tanks, is by further treatment in aërobic filters, purified 95 per cent.; requiring only about 12 mins. to pass through the filter.

The process is purely aërobic and automatic. The effluent from the septic tanks is distributed from holes bored in the pipes *AA*, and after being supplied with oxygen, to give life to the bacteria during its passage through the filter, it is discharged into the drain *B* through the pipes *CC* inserted in the side walls of the chamber.

Instead of employing perforated pipes for the distribution of the effluent, tipping troughs of any convenient form, which automatically spread the sewage water over the surface of the filter, as soon as they become full, can be used, as shown in Fig. 3. The gradual discharge from perforated pipes is however preferable, as the action of the tipping troughs tends to disturb the surface of the filtering material and form ridges.

In all forms of aërobic filters, the size of the filtering material is more important than its composition, but rough surfaces such as coke, coal and brick give better results than comparatively smooth particles like broken stone.

The bottom foot in depth of filtering material should be from $\frac{1}{2}$-in. to 1-in. cubes, the upper may vary from $\frac{1}{8}$-in. to $\frac{1}{2}$-in. in size, but the material should be sharp and clean. No fine sand or dust should be used, as it tends to clog the

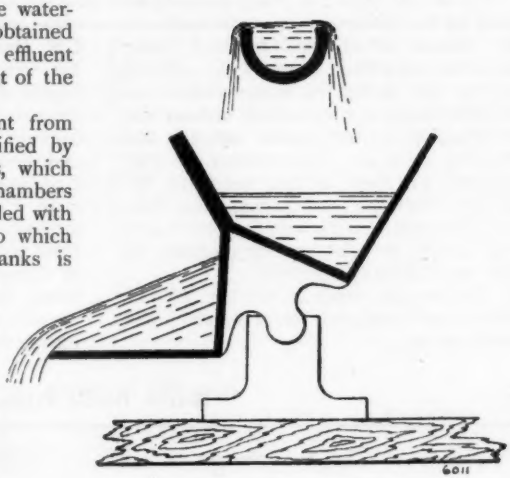


FIG. 3.—DETAILS OF TIPPING TROUGH.

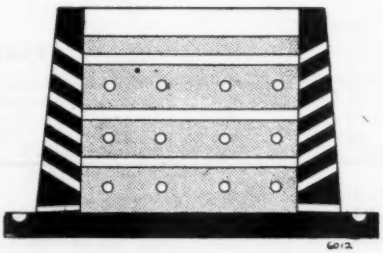


FIG. 4.—COL. DUCAT'S FILTER.

spaces between the larger particles, and prevents the free oxidization of the fluid.

From two to three feet is the best depth of filtering materials, and though slightly better results can be got from deeper filters, the extra fall required to work them can rarely be obtained without loss of irrigating power or resort to some sort of pumping.

The results given by coal and coke filters are invariably good, but the material requires careful washing before it is placed in the filters, otherwise the effluent carries off the small particles, and will be dark-coloured for a considerable time.

The simple filter described can only be used for the effluent from septic tanks, or for sewage which has received some previous anaërobic treatment. Crude sewage can under no circumstances be discharged on to such a filter without fear of clogging up the spaces between the filtering material. These filters are continuous in their action, receiving the effluent from the septic tanks, either from the drippings from the supply pipes or from the tipping troughs, as they gradually fill and automatically overturn.

An average analysis of the effluent discharged from such filters is given in the table below :—

delivered direct to the filter. The best type of this class is that invented by Col. Ducat, and its design is based on the fact, that by a free and continuous supply of oxygen to the sewage, as it drips through the filtering material, the aërobic bacteria are largely increased in numbers and their work in breaking down the solids facilitated.

In Col. Ducat's design this result is attained by piercing the side walls of the filter with numerous pipes, 3 ins. to 4 ins. in diameter, the inner ends of the pipes being lower than the outer, so as to prevent any leakage of the sewage effluent during its passage through the filter. At

Burnt Brick Filter.

Total Solids.	Suspended Solids.	Chlorine.	Free Ammonia.	Albd. Ammonia.	Nitrites.	Nitrates.
40·00	*Nil.*	4·80	3·320	0·098	0·368	Abundant.
27·00	*Nil.*	3·10	0·116	0·132	0·552	6·80
21·00	*Nil.*	3·00	0·584	0·088	0·1004	0·88
			Coal Filter.			
20·00	*Nil.*	3·00	0·176	0·084	0·496	3·90
18·00	*Nil.*	3·20	0·334	0·088	0·056	6·30
22·00	*Nil.*	3·40	0·005	0·024	0·0506	8·85

The aërobic filter just considered possesses the great advantage that it can be successfully worked with a head of from only 2 ft. to 3 ft. This low working-head is a matter of the utmost importance; even with this slight loss it is often impossible to get the purified sewage on to the land to be irrigated, without resorting to pumping either the crude sewage or the effluent.

In the tropics, where the work of the bacteria is helped by the heat, sewage can be purified 99·6 per cent. in a septic tank, when followed by the treatment of the effluent in an aërobic filter, with a loss of head of only 3 ft.

We may now consider briefly another class of aërobic filter in which sewage can be purified without any previous treatment in septic tanks, the crude sewage being

short intervals perforated pipes, connected to the inner ends of the wall pipes, are run horizontally through the filtering material.

The construction of the filter will be readily understood by a reference to Fig. 4; the filtering material being burnt brick or coal, the first two or three feet in depth broken to from $\frac{1}{4}$ to $\frac{1}{8}$-in. cubes, followed by three ft. in depth of $\frac{1}{2}$-in. cubes, the bottom layer being of the same sized material as the top. The sewage is delivered by tipping troughs and requires from 40 to 45 mins. to pass through the filter. Crude sewage can be purified 95 per cent. at the rate of 500 gals. per sq. yd. per diem.

A fair average analysis of crude sewage from small communities and of the effluent from the Ducat filter are given below.

Analysis of Crude Sewage.

Total Solids.	Suspended Solids.	Chlorine.	Ammonia.		Nitrites.	Nitrates.
			Free.	Albuminoid.		
232·00 Mineral Solids ... ... Suspended Solids	192·00 = 86·00 = 192·00	5·00	2·64	0·96	*Nil.*	*Nil.*
500·00 Dissolved Solids	390·00 = 110·00	8·40	2·54	1·88	*Nil.*	*Nil.*
410·00 Dissolved Solids	350·00 = 60·00	3·80	2·452	1·80	*Nil.*	*Nil.*
Average ... 380·67	310·67	5·73	2·531	1·253	*Nil.*	*Nil.*

Analysis of Effluent.

52·00 Organic Solids ... ... Mineral Solids	*Nil.* = 44·00 = 8·00	6·00	0·132	0·088	0·11	14·50	12-12-00, 8·15 A.M.
58·00	*Nil.*	5·80	0·005	0·052	0·0276	12·66	14-12-00, 2·45 P.M.
54·00	*Nil.*	4·30	0·096	0·062	0·05	13·50	16-12-00, 7.45 P.M.
Average ... 54·67	*Nil.*	5·367	0·077	0·067	0·625	13·555	...

The only drawback to the Ducat filter is the great depth, generally about 8 ft., required for the complete purification of the sewage. The filters are continuous and automatic in their action, and seldom require cleaning. The effluent is exceedingly good, and a greater amount of sewage can be dealt with by them, in a shorter time and on a smaller area, than by any other form of treatment.

We may now turn our attention to two questions second only in importance to the purification of the sewage—viz. the effect of continued application of the effluent to the land, and the most remunerative crops to grow.

As already stated, crude sewage should never be used; it rapidly coats the land with a layer of decomposing organic matter, resulting in the land becoming "sick," and creating a nuisance. Again, while the crops grown from the purified effluent are luxurious and succulent, the crops from land treated with crude sewage are rank and coarse.

With purified sewage the condition of the land gradually improves, and 5,000 gals. of effluent per acre per day can easily be used, with a larger quantity on sandy or porous soil. In spite of the large quantities of fertilising material contained in the effluent, the land, when continuously cropped, is apt to get exhausted, owing to the rapid growth of the crops under a tropical sun; it is therefore always advisable to allow one quarter of the area to lie fallow for short periods, so as to give the land a rest. In India green fodder crops are the most lucrative, and the sewage being generally only available near large towns, there is always an assured market. Vegetables thrive well on land irrigated by the purified effluent, such sorts as cabbages, cauliflowers and similar plants quickly attaining a great size without becoming in any way rank or coarse.

Irrigation by means of furrows is usually practised, but basin irrigation and flooding by check levees may with advantage often be resorted to.

The most paying crops are lucerne, or alfafa, jowari, guinea-grass and maize.

The lucerne is cropped over and over again; the roots spread in a mat under the ground and the return improves month by month. The out-turn is slightly under $2\frac{1}{2}$ tons per acre per cutting, and a crop a month can easily be grown at this rate.

Maize, with a crop once in six weeks, gives an out-turn of about 10 tons per acre per cutting.

Jowari will give a fodder crop once in two months, the out-turn per acre, per cutting, being about 18 tons.

Maize and jowari require sowing anew for every crop, while lucerne and guinea-grass only require cutting.

Root crops, such as turnips, carrots, beet, etc., flourish with effluent irrigation, and there is generally a ready market for such vegetables.

Plantains and other similar fruit-trees may with advantage be grown round the outskirts of a sewage farm.

One overseer, five gardeners, and 20 labourers could easily cultivate seven to eight acres, one quarter of the area being always allowed to lie fallow; and, considering the low rates of wages in India, a profit of from 15 to 20 per cent. on the total capital outlay may be anticipated.

Better results have already been attained under most unfavourable conditions of soil and climate.

E. O. MAWSON
(P.W.D., Bombay).

It has been represented to us from time to time by numerous readers and advertisers that the title at present borne by this Journal does not adequately describe its position in the literature of technology, nor does it indicate the thoroughly technical character of its contents.

It has been decided therefore that, commencing with the JANUARY Number of 1904, the title will be altered to

THE ENGINEERING REVIEW

FORMERLY

FEILDEN'S MAGAZINE.

Foundry Core-making Machines.

ALTHOUGH machines for producing cores have been on the market for many years, yet, owing to the tendency amongst many foundry managers to consider machines for this purpose as somewhat in the nature of a fad, developments in this class of machinery have not been considerable. When one considers the usual methods of making cores in the average foundry, and thinks of the slow process of producing a core of ¾ in. diameter by 10 ins. long, using a wooden core-box, and ramming each half by hand, it appears that in many cases a suitable core-making machine would easily reduce the cost of production, besides increasing the output. Many times, when discussing the cost of core making with foundrymen, the writer has been met with the statement, "Oh, our small cores are made by the boys, and cost practically nothing for labour," forgetting that the wooden core-boxes used are costly to produce, and unless carefully used and kept in repair the cores made are far from the desired shape.

Of course, if tubes are used for round cores better results are obtained; but, even with the smoothest tubes possible to procure, it is difficult to make a round core over a few inches in length, and a greater amount of skill is necessary to ensure the core being made with a proper vent-hole. A large number of short square or round cores, such as are used for bolt-holes, etc., and are required to be sent to the moulder the right length, can always be made very rapidly in iron boxes, containing, perhaps, up to a dozen cores. Messrs. Dobson & Barlow, Bolton, make cores of the above description in iron blocks, turning them out at a greater rate per hour than any machine I have seen could attempt. I believe a Manchester firm some years ago experimented with a machine for making both small round and square cores, on the principle of forcing the sand through a metal block with six or eight holes of the section required; but difficulties were experienced in venting and handling the cores.

A good point in favour of machine-made cores, when compared with the hand-made from halved core-boxes, is the great advantage to the machine department in boring out a cored hole if it be perfectly round and straight when given into the machinist's hands; most cores made from the usual core-boxes being more or less oval, according to the condition of the boxes. Various other points are put forward by the makers of core-making machines, some of which are good, others doubtful, and in the following description of a few machines now being offered by various makers, most of which have been personally worked, it is intended to illustrate and point out the advantages and disadvantages of the several types.

A core-making machine in extensive use on the Continent, and which, during the

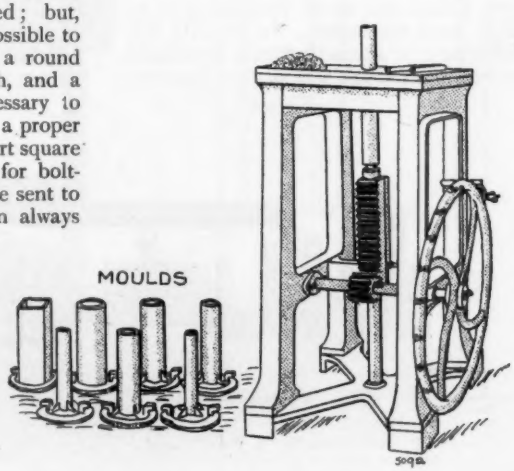


FIG. 1.—THE PHILLIPS CORE-FORMING MACHINE.

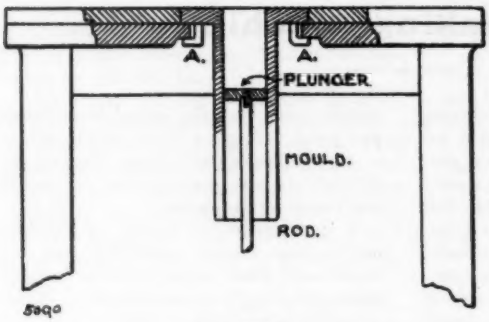


FIG. 2. FIG. 3.

SOME DETAILS OF THE PHILLIPS CORE-FORMING MACHINE.

last five years, has been adopted by many leading firms in this country, is the Phillips core-forming machine, illustrated by Fig. 1, sold by Messrs. J. W. and C. J. Phillips, London. This machine is made in four sizes, the smallest making cores to 2 ins. diameter by 11½ ins. long, and the largest up to 12 ins. diameter by 16 ins. long. The action of the machine is very simple, the sand being fed into the mould from the flat table top as shown, the operator taking care to ram lightly, as if the sand is tightly rammed some crushing action takes place on the first inch or so of the core before the whole length begins to slide from the mould. In working this machine it is advisable to ram the mould rather tightly at the bottom, then inserting the vent-wire and carrying-irons if used. No special mixture of sand is necessary, the usual loamy sand being quite suitable. For cores of medium diameters within the lengths of the moulds, a man can make cores far quicker than by hand. The makers claim that an ordinary workman can, with a little practice, turn out in eight hours the following cores :—

800 to 900—¾ in. to 1 in. diameter ; or
400 to 500—1 in. to 2 ins. diameter ; or
300 to 400—2 ins. to 3 ins. diameter ; or
250 to 300—3 ins. to 4 ins. diameter.

Square cores, or any section within the limits of the machine, can be turned out at a proportionate rate of speed. The ordinary square moulds sent out with the machine, when required, can be easily

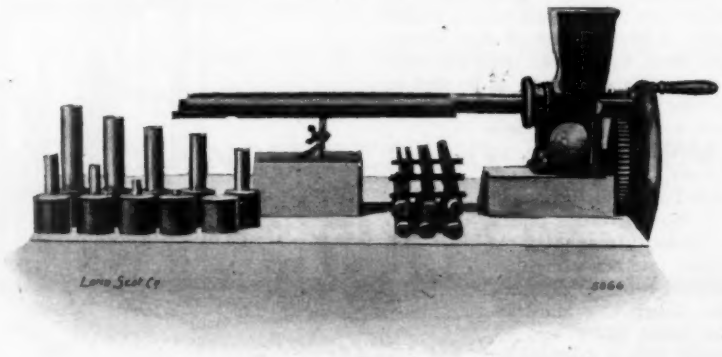


FIG. 4.—THE WADSWORTH AND SHERWIN CORE-MAKING MACHINE.

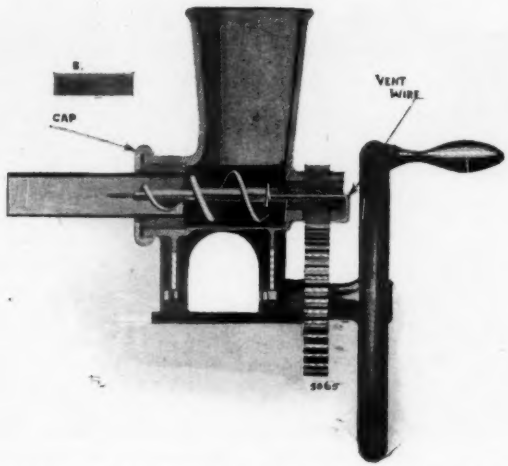


FIG. 5.—SECTIONAL VIEW OF WADSWORTH AND SHERWIN'S CORE-MAKING MACHINE.

FIG. 6.—THE THOMAS AND CLARE CORE-MAKING MACHINE.

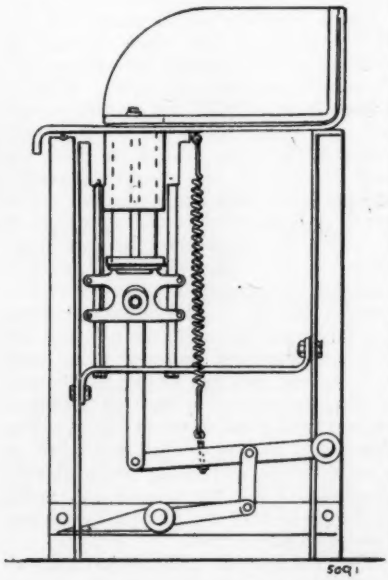


FIG. 7.—SECTIONAL VIEW OF THE THOMAS AND CLARE MACHINE.

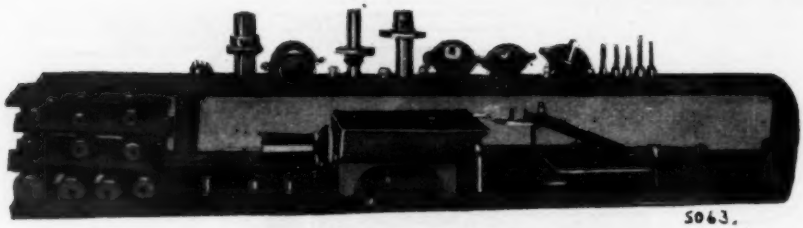


FIG. 8.—THE PYOTT CORE MACHINE.

altered to any special section—say, a rectangular or T-core—by inserting wooden insets or strips, these being pushed out by the plunger with the core. It is also claimed that stepped cores, *i.e.* cores not of parallel section, can be made with the above method of placing wood strips inside the iron moulds; but in practice this does not answer very well, the average core-maker not being sufficiently careful to admit of leaving him any chance to vary perhaps an important dimension.

Fig. 2 shows a partial section of the Phillips machine, from which the method of changing and fastening the various sizes of moulds can easily be seen. A flange is formed on each of the moulds at one end, this being machined to fit in the recess in the table. No loose parts are used to secure the mould, a simple bayonet joint holding it in position. The recess is formed with two openings, as shown in Fig. 3, to allow the two finger pieces *A A* to pass through in position. Each size of mould is provided with a plunger, see Fig. 2, the recess on lower side fitting on the end of the rod from the rack, a countersunk set-screw being used to keep the plunger secure. The rack carrying the rod and plunger has an ample bearing surface, as shown in Fig. 3. The hand-wheel on pinion shaft is marked in equal divisions, and being provided with an adjustable stop the operator can readily fix the position of the plunger to suit any desired length of core.

The machine as above described, although not really a core-making machine, as all the ramming has to be done by hand, will, owing to the convenient position of the mould for filling in the sand, and the quick method of ejecting the core, show a considerably greater output for suitable work than the best core-boxes rammed by hand.

The Wadsworth & Shirwin core-making machine, a general view of which is given by Fig. 4, has only a limited range when compared with the Phillips machine, but for cores from $\frac{3}{8}$ in. to $2\frac{1}{4}$ ins. diameter the rate of production is greatly in excess of the figures previously given. The maximum output as given by the makers as a record is as follows :—

220 ft.	2½-in. core.	504 ft.	1¼-in. core.
260 ,,	2¼ ,, ,,	576 ,,	1⅛ ,, ,,
272 ,,	2 ,, ,,	600 ,,	1 ,, ,,
288 ,,	1⅞ ,, ,,	550 ,,	⅞ ,, ,,
336 ,,	1¾ ,, ,,	520 ,,	¾ ,, ,,
360 ,,	1⅝ ,, ,,	468 ,,	⅝ ,, ,,
360 ,,	1½ ,, ,,	240 ,,	½ ,, ,,
432 ,,	⅜ ,, ,,	216 ,,	⅜ ,, ,,

The above result was obtained with the machine running at 300 revolutions per minute, or about twice the usual speed, so if we say 5 ft. of 1-in. diameter core per minute, or 300 ft. per hour, a good idea of the output of the machine can be gathered. The writer has made three lengths of ¾-in. diameter core in one minute, each length 2 ft., and turning the machine by hand. Of course, in considering the figures given, the time taken in changing moulds, mixing the sand, etc., must be added.

The section of the Wadsworth and Sherwin machine given by Fig. 5 explains itself fairly well, and shows clearly the action of the spiral conveyor in forcing the sand into the mould. Great care needs to be taken when working the machine, as if the sand is not fed on the spiral conveyor slowly and steadily, the

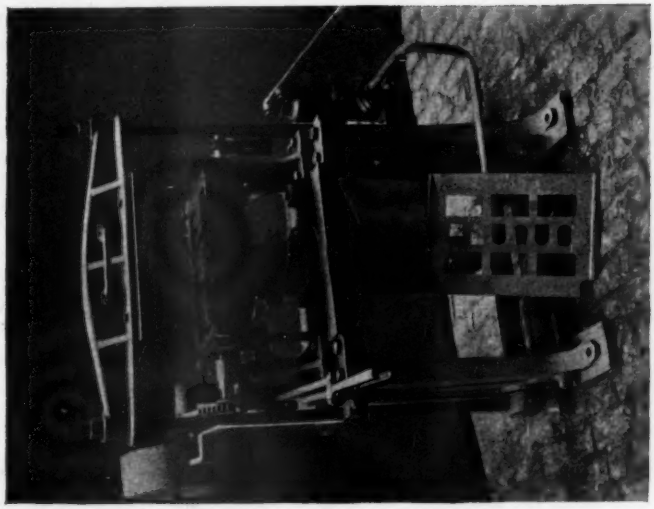


FIG. 9

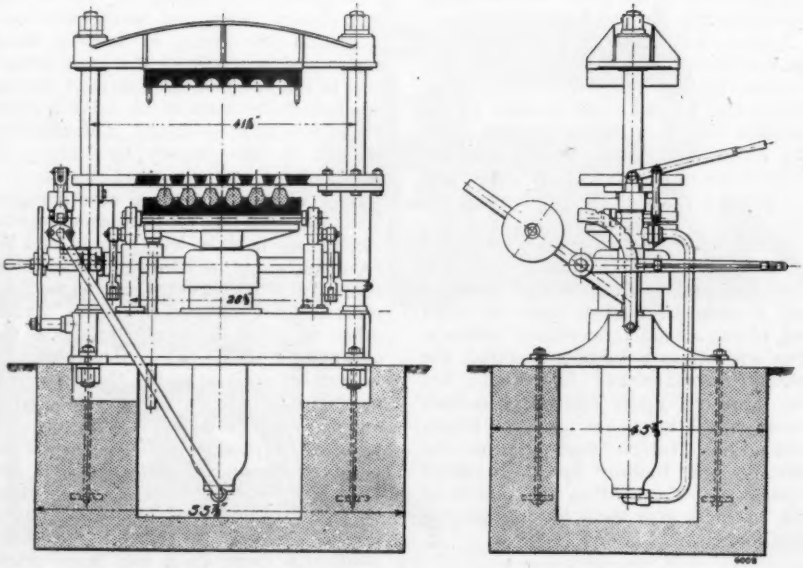


FIG. 9A.

FIGS. 9 AND 9A.—THE LONDON EMERY WORKS COMPANY'S CORE-MAKING MACHINE.

sand will accumulate in the hopper instead of passing along the mould. This feeding is done in a similar manner on the Hammer core-making machine, but a worm is fitted to keep the sand moving in the hopper. This is hardly required, as if the operator has the machine properly fixed, so that he can see the spiral worm or conveyor revolving, he can regulate the feed to suit the particular size of core in hand, especially if the machine is driven by belt. The machines are made with a combined hand-wheel and pulley; in either case the core-maker would have no difficulty in attending to the feeding.

The moulds are changed by removing the cap, shown in Fig. 5, when the large end, which is the same size in all the moulds, can be withdrawn. As each size mould requires a differently pitched screw conveyor, care has to be taken that the correct size is used; the method of fixing these screw conveyors in position is by means of the shank end, a small length of this being made half round, the outside end of the pinion being machined to suit, and the thrust of the screw when working preventing any working loose.

A special point of interest to moulders in the Wadsworth and Sherwin core-making machine is that every core is perfectly vented end to end; this is done by the vent-wire shown on Fig. 5. In the 2-ins. and 2¼-ins. diameter cores this wire has an extra piece, *B*, screwed on small end, this giving a $\frac{5}{16}$-in. clean hole through the core.

When using this machine it was soon found that the usual loamy sand was unsuitable; the best results were obtained with a silica sand taken from the river-bed, adding a small proportion of common flour and oil as a binding material, the makers recommending linseed-oil; but one firm of cotton machinery makers known to the writer get excellent results from a cheap fish-oil imported from the States. The Railway Speed Recorder Company, of Kent, Ohio, the makers of this machine, give the following proportions for mixing the sand:—

6 quarts of silver or lake sand;
1 quart of flour;
½ pint raw linseed-oil.

It will readily be seen that the above quantities will require to be varied nearly in every case, as the sand used in one foundry may vary largely from what is used in another. The best results are not obtained by any fixed quantities of sand, flour, and oil, but by carefully trying the sand available until the mixture leaves the machine easily. Of course, in many cases the amount of flour and oil given above can be materially reduced. A point to be kept in mind with these rotary action core-making machines is not to attempt to force the machine in any way, as if the proper dampness of the sand is obtained, a 2¼-in. diameter core leaves the mould or die as easily as a ½-in.

The Wadsworth and Sherwin core machine is made perfectly interchangeable, the gears cut, and as all parts are numbered replace parts are readily obtained. A number of these machines are working in this country, making various sizes of cores; and there can be no doubt that for a large number of iron-founders a machine of this class will soon return the initial cost through the saving in time at the core bench alone, not taking into consideration the saving in keeping wood core-boxes in repair, or the great advantage to the machine shop through having machine-made cores which leave a clean round hole in the castings. This machine is sold in this country by Horace P. Marshall & Co., engineers, Leeds.

The Thomas and Clare core machine is an American type for turning out rapidly small cores in short lengths only, and for foundries using a number of duplicate cores. It would appear that this machine removes the objection made to several other types of core machines, *i.e.* the cutting to a dead length. This objection is certainly serious, as the time taken in cutting long lengths of core to, say, a couple of inches, takes away the saving of time when producing. Of course, the point of drying in the stove with less labour in handling and space occupied tells in favour of the long lengths, but if a core stove on the Millet principle is used, the short cores are easily dried. Without doubt the Thomas and Clare machine is the first machine to deal

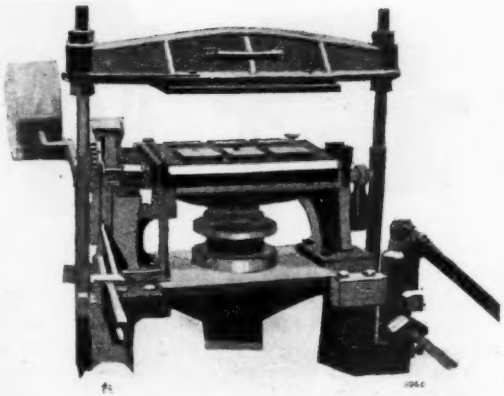


FIG. 11.—READY FOR PRESSING AGAINST UPPER CORE BOX: INTERMEDIATE PLATE BEING REMOVED.

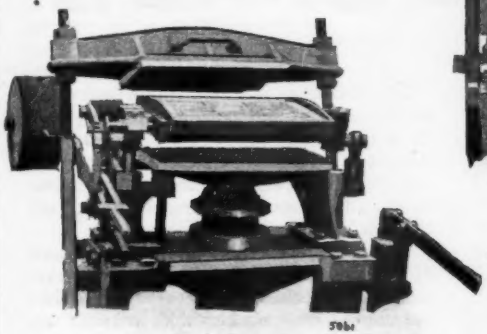


FIG. 10.—READY TO RECEIVE THE CORE SAND. THE INTERMEDIATE PLATE RESTING ON THE LOWER CORE BOX.

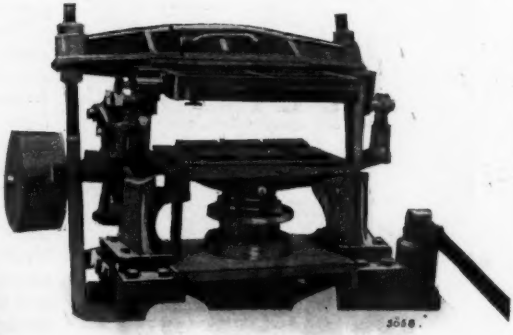


FIG. 13.—THE CORES READY TO GO INTO THE OVEN. LOWER CORE BOX TURNED OVER, AFTER A PIECE OF SHEET IRON HAS BEEN PLACED ON TOP OF IT TO RECEIVE THE CORE.

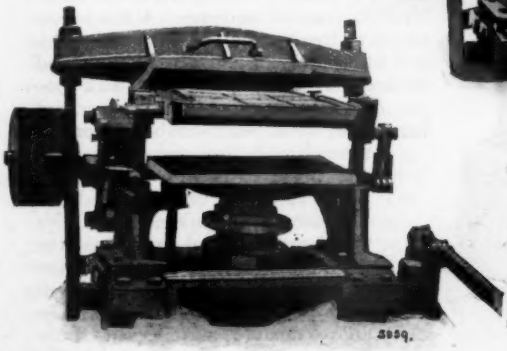


FIG. 12.—AFTER PRESSING: PRESS CAP WITH UPPER CORE BOX SWUNG BACK.

FIGS. 10 TO 13.—FOUR POSITIONS OF THE HYDRAULIC CORE-MAKING MACHINE WHEN MAKING RECTANGULAR-SHAPED FLAT CORE.

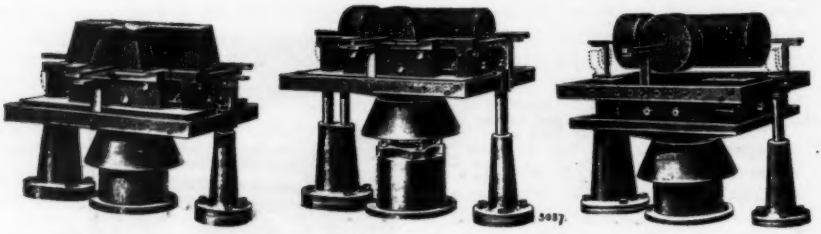


FIG. 14.—METHOD OF MAKING LARGE T-SHAPED CORES.

expeditiously with short cores to a fixed length. The machine, it will be seen from the general view (Fig. 6), is somewhat similar to the Phillips core-forming machine shown in Fig. 1, the chief difference being that no hand-ramming is required, as in the Thomas and Clare machine the sand is pressed to the necessary density by the plunger, the covering plate, shown on the general view, preventing the sand from being forced back on the bench.

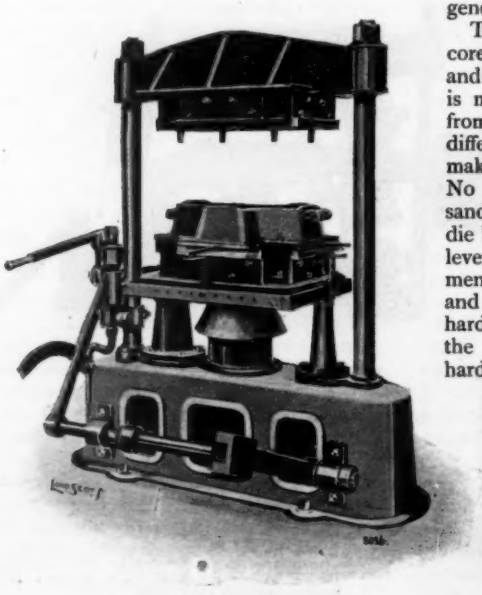


FIG. 15.—HYDRAULIC CORE-MAKING MACHINE

The machine is intended to deal with cores $\frac{5}{8}$-in., $\frac{3}{4}$-in. and $\frac{7}{8}$-in. diameter to 3 ins. in length and 1-in., $1\frac{1}{4}$-in. and $1\frac{1}{2}$-in. diameter to 4 ins. long, and as in the smaller designs eight to ten cores can be produced at the same time, the output of the machine can be imagined.

The sectional view of this machine (Fig. 7) shows how the dies and plungers can easily be changed, and also shows the substantial and workmanlike manner in which the machine is built, a noticeable point being the absence of cast iron, generally so common in foundry machines.

The Pyott Core Machine produces cores of any section up to 4 ins. diam. and to any desired length. The machine is made in Chicago and, as will be seen from the illustration Fig. 8, works on a different principle than other small core-making machines described in this article. No rotary movements are required, the sand being fed from the hopper into the die by a plunger worked from the hand-lever at rear of machine. A few movements of the lever fills the die with sand, and the core can be made of any desired hardness by pressing the sand back into the die when starting until considered hard enough. A clean vent-hole is formed through each core, and if the cores are preferred with strengthening wires, these can easily be used, the machine being adapted for this purpose. The makers suggest the following mixture in preparing the sand: 18 gals. of sand, 3 gals. of flour, 1 qt. raw linseed-oil. The above mixture may appear somewhat expensive, but probably the quantities of flour and oil could be

reduced considerably. The Pyott core machine is sent out with trays to carry the cores when coming from the mould and with round moulds ¾ in. to 3 ins. diameter. Other sizes and sections being extra.

The core-making machines already described are practically no use for cores other than of parallel sections, and do not cover the large field presented when one thinks of the variety of cores, often made in quantities by firms constantly turning out repetition work, such as stop-valves, plug-cocks, taps, pipe-elbows, and connections used and made by the thousand. Although these castings can be, and generally are, made on one or other of the excellent moulding machines now offered by several makers, the cores have to be made from specially-made core-boxes, both expensive to produce and keep in repair, besides costing, in many cases, more to make than the actual mould. A machine designed for dealing with this special class of work is offered by The London Emery Works Company, a general view being given by Fig. 9. It being obvious that a core of varying thicknesses would not be equal hardness if pressed at one operation, preliminary cores are made from dies or pattern plates slightly larger than the finished cores will be. The intermediate plate is then removed, as shown by Fig. 9. In the larger machines this plate is arranged to swivel on one of the pillars. The upper and lower plates are then brought together, the core being completed by a final pressure. An example of the method employed is clearly shown by the following sketches (page 498).

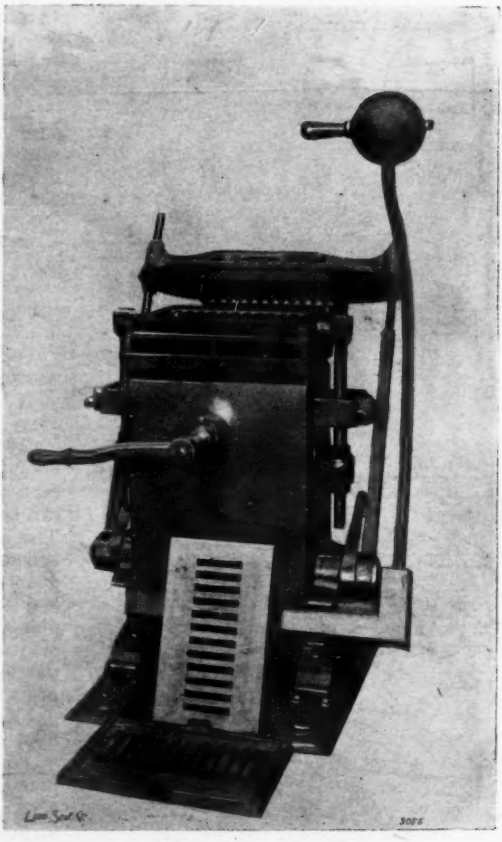
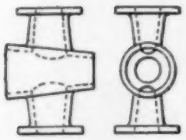


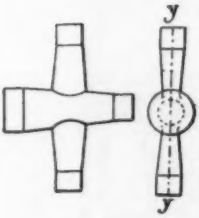
FIG. 16.—HAND-POWER CORE-MAKING MACHINE BY THE LONDON EMERY WORKS CO., LTD.

From the perspective views shown of the upper and lower plates it will be seen that small grooves, *e e*, are cut round the outline of the core, these being intended to take any sand which would otherwise tend to prevent the upper and lower plates from making a close joint when the power is applied. When only one core-making machine is used for a variety of work, the plates can readily be changed, the upper plate being attached to the press cap as shown. The lower plate is carried on a turnover table, so the cores can be left on a sheet-iron plate, as shown by Fig. 13, for removal to the store.

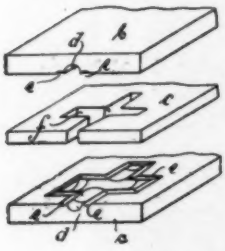
The illustrations Figs. 10, 11, 12, and



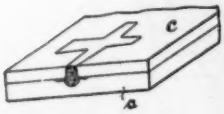
Example of a standard article, such as a cock, in plan and elevation.



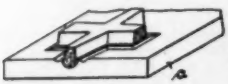
The core for the same in the two corresponding views.



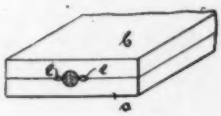
The core-boxes, three in number, shown in perspective.



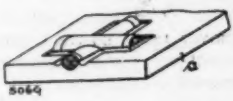
The preparation of the *preliminary* core on the lower and intermediate core-plates.



The *preliminary* core lying on the lower core-plate, the intermediate plate being removed.



The upper and lower core-plates in contact.



The *finished* core resting on the lower plate.

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13 give four positions of the hydraulic core-moulding machine when making rectangular-shaped flat cores, and show very clearly the substantial construction of the machine, together with position of the hydraulic ram, pump, balance-weight, and other working parts. The makers state that the machine can be adapted for working with air or steam in addition to the hand type illustrated. If compressed air is available it would add to the advantages of the machine when compared with water or steam power, the latter in particular being a decided source of trouble in most foundries where used.

For producing cores of larger size than already shown, such as pipe cores, T-pieces, etc., similar to the T-piece illustrated in Fig. 14, the work is even more simple. The cores are made in green sand in precisely the same manner as moulds, and each core being provided with a core-iron can be at once lifted from the core-plate. This can be done either by the projecting ends of the core-iron being made to rest upon the angle-irons of the lifting frame, and being raised by a lever before the plunger carrying the core-plate is lowered; or else by raising the lifting frame after the plunger has reached the lowest point of its stroke.

The advantage of being able to make these large cores from ordinary green sand is no small one, especially where large numbers of castings of the same size are constantly being made. The time saved in making the cores is considerable in itself, without counting the cost of drying, and the lower cost of the inferior sand used. The makers of this machine claim that 30 T-shaped cores $7\frac{1}{2}$ ins. diam., similar to the ones illustrated, Fig. 14, can be made in one hour by two men. The substantial nature of the large size machine is shown by Fig. 15. This view also shows how the requisite amount of sand is prepared before the final pressure is put on the core.

Fig. 16 is a photograph of a core-making machine, made by The London Emery Works Co., Ltd., having an arrangement of levers operated by hand-power, somewhat similar to the hand-press moulding machines, which are now being generally

FIG. 17.—SHOWING MACHINE AS USED ON A TAPER CORE.

introduced. A noteworthy point, and one which makers of foundry machines usually omit, is the neat method adopted in protecting the working parts from sand, sheet-iron being fitted round the machine. The following particulars of the output of these machines have been given by the makers :—Cores for large branch pipes,

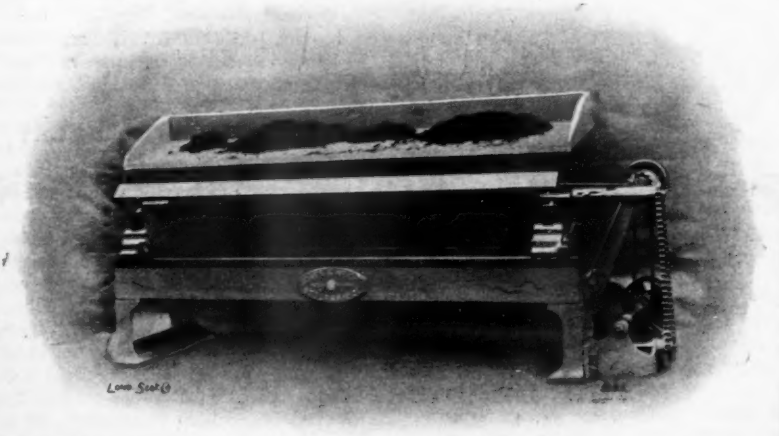


FIG. 18.—MACHINE WITH 2-IN. RAIN-WATER PIPE CORE.

FIGS. 17 AND 18.—CORE-MAKING MACHINE BY MESSRS. JONES AND ATTWOOD FOR MAKING LONG CORES.

60 ins. long, 8 in. diameter, one man can make one core in ten minutes. The small-size machine, with pattern plate 15 ins. by 8 ins., made 120 cock cores per hour, three cores being made on each plate. These results show that, given suitable work, a very large saving over hand labour is possible with these machines.

None of the core-making machines previously described are able to deal with lengthy cores, such as are so extensively used by founders making ordinary pipes for water, steam, etc., or builders' pillars or columns. Mr. Walter Jones, of Messrs. Jones & Attwood, Stourbridge, has recently placed on the market a machine for dealing with this class of work.

From the general views of the machine —Figs. 17 and 18—it will be noticed that ordinary core barrels are used, no alteration to the usual type being required, the roller bearings provided for supporting the core barrel being adjustable. The barrel is revolved by means of a chain drive worked from a worm on the main pulley shaft, the attachment being made with a sleeve coupling to the end of the core-barrel. The second chain drive, shewn working direct from the main pulley shaft on to a short countershaft a little above the centre of the core barrel, has a face-plate crank on the end; this gives a reciprocating motion to a connecting-rod fixed to the flat steel bar, shown immediately under the shelf carrying the sand. This steel bar is adjustable to any position for various diameters of cores, and can also be set for taper cores, as is actually shown in the illustration. The machine being provided with fast and loose pulleys, the operator has simply to feed the sand to the moving steel bar, and a core is rapidly produced, the reciprocating action firmly pressing the green sand to the core barrel.

Ordinary green sand is used, and as the thickness of sand on the barrel is small, the cores can be dried in a short time, or, if urgently required, they could be used in the mould immediately. This, together with the use of unskilled labour, would undoubtedly effect a great saving over the makeshift methods often adopted in striking up loam cores.

The machine will make cores either parallel, taper, or for socket pipes, from 2 ins. to 12 ins. diameter, and any length from 9 ins. to 9 ft., and the patentees assert that the economy effected in weight, time, fuel, core material, labour, and the increased output on a given floor space, shows a saving of from 5*s*. to 10*s*. per ton on the cost of production.

A point which should not be overlooked in comparing these machines made with loam cores is the difference, which is easily imagined, of removing the cores from the castings, the green-sand core being more quickly removed than the hard-baked loamy one.

Messrs. Jones and Attwood are prepared to supply machines on approval, and to send competent men to start and work them if desired.

JAMES R. KELLY.

It has been represented to us from time to time by numerous readers and advertisers that the title at present borne by this Journal does not adequately describe its position in the literature of technology, nor does it indicate the thoroughly technical character of its contents.

It has been decided therefore that, commencing with the JANUARY Number of 1904, the title will be altered to

The Engineering Review,

formerly

Feilden's Magazine.

Conditions Governing the Production of Steam Metal Alloys.

(Continued from page 418.)

II.

In the former article some of the general conditions governing the production of these alloys were examined. Generally speaking these conditions are not largely responsible for many of the failures on steam or water trial. For instance, the presence of impurities may be readily detected by chemical analysis, abnormal crystallisation is minimised by proportionate design in the patterns, and foundry practice may readily be brought up to such a pitch as to obviate faults due to moulding, &c. Further, if failures were due to impurities originally present in the constituent metals, or to abnormal design of the pattern, then all the castings of a given series would meet with rejection on steam or water trial. Therefore, in the event of a whole batch of castings failing to withstand a certain pressure, it would be well to examine for impurities or for faulty design, but rejections of so wholesale a character are the exception, and by no means the rule. The prevailing conditions are rather those in which, from a series of castings of the same alloy, moulded from the same patterns, the majority pass a steam or water trial, whilst a few hopelessly leak. In other words, castings of identical composition, made under, as far as known, identical conditions, are not always uniform in their resistance to the passage of steam or water. Further, the castings which leak cannot be distinguished from the sound ones, their appearance before and after machining is the same, and the only possible way of picking them out is by actual trial. Under such conditions the chemical composition of the alloy cannot be at fault, for it is the same throughout, and may be readily checked by analysis. Given a chemical control of the alloys, and uniform conditions prevalent in the foundry, uniformly good castings should follow, but as a matter of fact they do not. Turning to the foundry conditions quoted in the previous article, it will be seen that uniformity may be readily secured in all essentials save one—that of the initial temperature at which the molten alloys enter the moulds. Therefore it would appear that an examination of this feature might possibly throw some light on the occasionally erratic behaviour of alloys which, in the majority of cases, yield castings capable of resisting extremely high pressures.

It is reasonable to suppose that the general character of any crystals on separating out, whether from a saline solution or from a gradually solidifying alloy, is influenced by the environment; in the case of alloys, particularly, by the hydrostatic pressure and initial temperature. Similar conditions must also hold good in the case of pure metals and certain pure elements, and the writer has found much variation in castings of copper, antimony, zinc, and even sulphur. Castings of these elements poured at different temperatures each present essentially characteristic features, due entirely to variation in casting temperature. For instance, Fig. 7 reproduces two fractures of antimony, one of which shows the normal fracture of the cast metal, and the other presents an almost perfect cleavage plane. These strips were cast from the same crucible, but at different temperatures, and both were broken by hand pressure. To break the normal bar a fair pressure was required; but the one showing a cleavage plane severed, as would be expected, on the least touch of the fingers.

That alloys, particularly steam metal ones, are influenced by varying casting

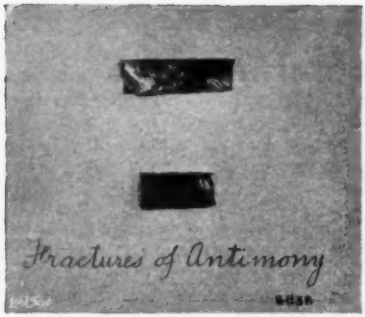


FIG 7.

temperature may be readily tested in any foundry by heating a crucible of gun-metal to the highest possible point and from this temperature casting a series of bars at intervals of one minute until solidification occurs. On mechanically testing these bars the tenacities will be found to rise with a falling temperature up to a certain point, from whence they again commence to fall. These results are exemplified if a large mass of the alloy be used in order that the crucible shall cool slowly and a fair number of bars be obtained for comparison. The bars may be in the form of rods 1 in. diameter by 10 ins. long, and should all be moulded in exactly the same manner. The writer has conducted many experiments of this type, and as far as gun-metal alloys are concerned it can be safely stated that where all conditions are uniform, save that of casting temperature, a variation in mechanical properties is bound to follow. This variation may be graphically represented as in Fig. 8. The highest point of this curve corresponds to the fair casting heat, that is the casting temperature at which the maximum properties of any given type of gun-metal are to be obtained. It will be evident that the extent of this fair casting heat is determined by the mass of the molten alloy; for with a 25-lbs. crucible, the contents of which naturally cool quickly, the fair casting heat would be represented by a sharp point or narrow time limit; on the other hand, with the contents of a 10-ton ladle slowly cooling, the "fair" heat would represent a proportionately wider range of time.

Not only is the variation in tensile strength shown by casting the same alloy under different conditions of casting temperature, but a marked alteration may be noted in the fractures of the bars as they pass from the highest to the lowest temperature. This point will be noted in considering the influence of casting temperature on microstructure. A further feature is the amount of feeding observed in the runner-head attached to the casting. In Fig. 9 a photograph of three gun-metal runner-heads is reproduced, the "hot" one shows no feed, in fact an actual expansion is shown by the ring of metal running two-thirds of the circumference of the head; the "fair" one shows a uniform feed occurring in all directions—this head was originally the same diameter as the foregoing one, but in process of uniform feeding it has lessened by settling down the funnel-shaped head mould; a further fall in temperature, as

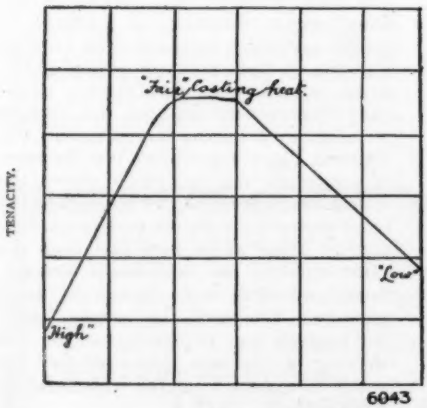


FIG. 8.

in the "cold" one, shows that the feeding tends to take the form of a central pipe. Evidently castings attached to heads, such as No. 1, will, when tested mechanically or by water-pressure, yield results inferior to similar castings attached to heads, such as No. 2. The feeding of No. 3 tending to take the form of a central pipe may give rise to local defects in the heavier parts of the casting, familiarly shown in the form of "draw-holes."

The following table, extracted from an earlier paper by the writer, shows at a glance the mechanical value of certain alloys poured at a known casting temperature.

All the gun-metals are of the same type, viz., Admiralty specification. The usual specification for gun-metal of this type is a tensile strength of not less than 14 tons per sq. in., and an extension of at least 7½ per cent. on 2 ins., and steam fittings are to withstand a working pressure of 1,700 lbs. per sq. in. Evidently then, castings of No. 1 or 3 would utterly fail to meet such a specification, and yet they are separated from No. 2 by the exceedingly narrow time margin of 2 mins. on either side. Nos. 19 to 21 represent gun-metal of the same composition, the three sets of bars were poured from one crucible at a "high," a shade below the "fair," and an exceedingly low casting temperature respectively. No. 22 represents a bar cut from a commercial casting, and is the highest tenacity the writer has yet obtained from this type of gun-metal. It must be distinctly remembered that the three gun-metals are of the same composition, and that the results embodied in the foregoing table are not laboratory ones, but were obtained under actual foundry conditions, and may be verified in any foundry by comparatively simple trial. The results obtained from the yellow brass, red brass, and muntz metal alloys are included in order to show their susceptibility to varying casting temperature; naturally they have no direct bearing on a study of steam metal alloys.

The gun-metals being chemically constant throughout, it must follow that the variation in casting temperature has some distinct structural effect on the internal formation of the alloys. In other words it evidently influences the cohesive force acting between the crystals. If the ten-

Influence of varying Casting Temperature on the Properties of Alloys.

"Proceedings" of Iron and Steel Institute, May, 1903.

Alloy.	No.	Casting Temperature, degrees Cent.	Maximum Stress Tons per sq. in.	Elongation per cent. on 2 ins.	Contraction of Area per cent.
Gun Metal ...	1 ...	1,173°	8·37	5·5	4·23
	2 ...	1,069°	14·83	14·5	16·71
	3 ...	965°	11·01	5·0	6·36
Yellow Brass ...	4 ...	1,182°	11·48	37·7	31·40
	5 ...	1,020°	12·71	43·0	35·66
	6 ...	850°	7·44	15·0	15·25
Red Brass ...	7 ...	1,308°	6·85	13·2	12·65
	8 ...	1,073°	12·64	26·0	30·28
	9 ...	1,058°	5·67	5·5	6·64
Muntz Metal ...	10 ...	1,038°	12·45	6·0	10·60
	11 ...	973°	18·88	15·0	16·10
	12 ...	943°	16·28	9·5	14·81
Gun Metal ...	19 ...	Three sets of bars from one crucible at various temperatures.	7·21	1·0	1·05
	20 ...		10·06	4·0	2·42
	21 ...		9·50	2·0	2·86
Gun Metal ...	22 ...	—	20·00	16·0	—

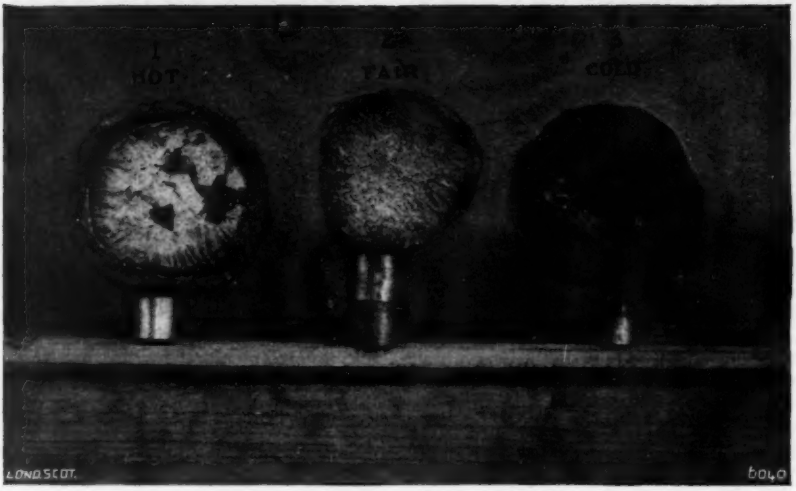


FIG. 9.

sile strength be taken as a measure of the crystal cohesion, then the tenacities already given clearly show that varying casting temperatures have a most marked effect on this cohesion, for values ranging from the low one of 7 tons per sq. in. to the high one of 20 tons have been obtained.

Microscopical examination throws comparatively little direct light on the cohesive force binding individual crystals together, and practically the only estimate of this force is that obtained by the tensile test; but apart from crystal cohesion a micrographic examination does throw a flood of light on the structural changes due to varying casting temperatures. A comparison of Figs. 12 and 13 sufficiently justifies this statement. The latter, as will be noted, shows no prominent crystal direction, and the whole structure more nearly resembles a forged than a cast alloy. On the other hand, Fig. 12 shows a most pronounced type of crystallisation tending to develop into definite cleavage planes; Fig. 11 approaches, but does not reach, the structure of Fig. 13; whilst Fig. 10 represents the structure of a high-temperature gun-metal casting. It may be added that Figs. 10 to 12 represent gun-metals 19 to 21, and Fig. 13 represents gun-metal 22 of the foregoing table. The structures of gun-metal 1, 2, and 3 are not reproduced in order to economise space, but in general they follow the same order as those of Figs. 10 to 12.

From wide micrographic examination of gun-metals of identical chemical composition, but cast under different conditions of temperature, the following conclusions may be drawn. Dividing the temperatures into "high," "fair," and "low," respectively, it is found that the high ones generally appear to favour a large, ill-developed type of crystallisation, giving a characteristically loose structure. Fair casting temperatures favour a distinct but yet interlocked structure, and the crystal junctions are not so marked as in the lower temperatures. Low casting temperatures give a most pronounced type of crystallisation, and the crystal junctions are very sharply defined, apparently forming routes along which fracture readily travels.

Comparing these conclusions with the accompanying photo-micrographs, some idea of the value of the various structures under steam or water trial may be obtained.

Thus the loose structure of the high temperature castings will allow steam or water under pressure to ooze through the microscopically minute interstices of adjacent crystals. The interlocked structure of castings poured at the fair heat effectually prevents any percolation of this kind, and the castings are therefore tight within all pressures up to their limit of deformation. The pronounced type of crystallisation familiar to the low temperature castings will—if the crystal junctions favour, which they generally do—offer routes of penetration in a similar manner to those of the high temperature castings.

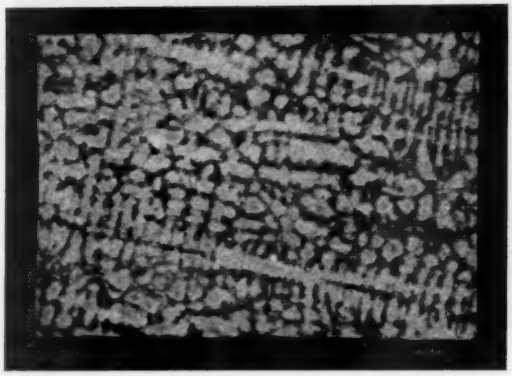


FIG. 10.

TENACITY: 7·21 TONS PER SQ. IN.
EXTENSION: 1 PER CENT. ON 2 INS.

Variation in casting temperature is therefore responsible for many of the occasional failures in batches of otherwise perfect steam or water resisting castings. As in the case of mechanical properties, this feature may be readily confirmed by casting a series of valve bodies, preferably flanged ones, at definite intervals from the highest possible temperature down to the lowest at which the alloy will flow.

Further, a casting failing to meet a certain pressure will, if re-melted and cast at a suitable heat, successfully withstand the pressure at which it previously leaked. This feature may be illustrated by the following tests. A gun-metal casting poured at an excessively low temperature yielded a tenacity of 6½ tons per sq. in. and an extension of 4 per cent. on 2 ins. On re-melting and casting at a suitable heat the results obtained were—tenacity, 15 tons per sq. in., and extensibility, 10 per cent. on 2 ins. The first casting was hopelessly porous, and the second one perfectly tight at a pressure of 1,000 lbs. per sq. in.

It must be stated that the casting temperature of any given alloy is not a constant factor, but necessarily varies with the weight, internal and external form of the casting, and so forth. This fact removes any difficulty lying in the path of the founder, for by arranging a series of boxes containing dissimilar castings, each requiring a slightly lower casting temperature than the preceding one, and pouring in rotation, it is evident that by suitable pauses between the boxes any variety of

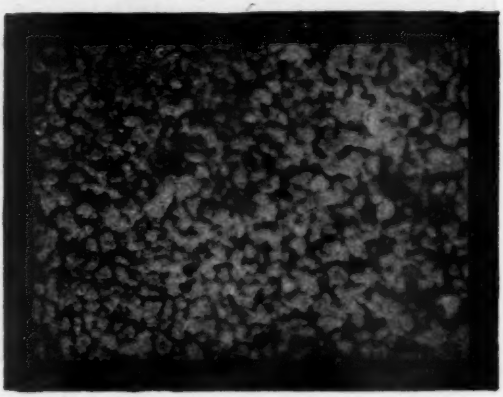


FIG. 11.

TENACITY: 10·06 TONS PER SQ. IN.
EXTENSION: 4 PER CENT. ON 2 INS.

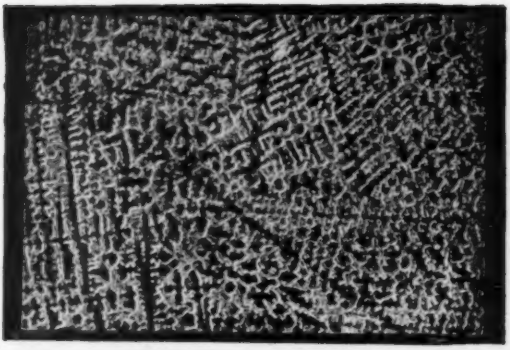


FIG. 12.

TENACITY: 9·5 TONS PER SQ. IN.
EXTENSION: 2 PER CENT. ON 2 INS.

casting temperature, within the limits of suitable fluidity, may be obtained. In the case of similar castings success will be obtained by commencing at a suitable temperature for the series, followed by extremely quick pouring. As already shown, the greater the mass of the molten alloy, the wider the time range of the fair casting heat; therefore, in practice, no insurmountable difficulties prevent each individual casting from being poured at a suitable heat, further than the one of successfully judging the correct temperature. If a pyrometer, permitting of carriage with the ladle, and capable of giving direct temperature readings—that is, without scientific interpretation—could be employed, then this latter difficulty would be readily overcome. However, such an ideal is rather sanguine; and whatever the future may bring forth, for the present the founder must rely on judgment alone. This judgment is, of course, a matter of experience; but in the course of daily work it may be trained to a high pitch, and by its careful exercise much improvement in the quality of the castings may be looked for. A note, however, is necessary here. Casting temperature should be judged in relation to the mechanical and steam-resisting properties of the casting, *not* to its appearance as it leaves the mould. Too often the temperature is viewed only as a means of producing castings of smooth skin and good external surface, a motive excellent in its way, but to which should be added the more important features of steam resistance and tensile strength. Experience in estimating suitable temperatures may be considerably strengthened by experiments of the type indicated in this article, in which the appearance of the alloy as it enters the mould is compared with the mechanical and other properties of the cold castings. Further assistance may be derived from the comparison of the feeding shown in runner heads. Obviously long-continued comparisons of this kind, in which visible temperature is correlated with mechanical and steam-resisting properties, will give a fund of definite data admitting of successful practical application.

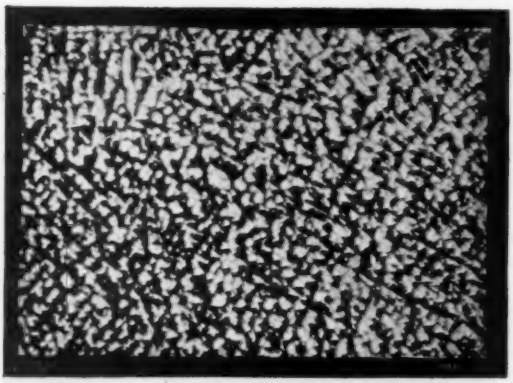


FIG. 13.

TENACITY: 20 TONS PER SQ. IN.
EXTENSION: 16 PER CENT. ON 2 INS.

PERCY LONGMUIR.

NOTES ON LOCOMOTIVE AND RAILWAY ENGINEERING.

Atlantic 4-4-2-type Locomotives on the Continent.

THE two locomotives illustrated on page 508 are representative of recent construction in France and Germany. Although differing widely in many respects, and being, so far as external appearance is concerned, wholly dissimilar, the two engines may be correctly described as of the same type, viz., the Atlantic or 4-4-2 type; moreover, both are four-cylinder compounds, and are intended for the same class of work—that of hauling fast passenger trains. The French engine is mainly identical with those of the celebrated 2·641-2·660 class on the Northern Railway, but has about 10 per cent. larger dimensions. Eight locomotives, similar in all respects to that illustrated, have been constructed at the Belfort Works of the Société Alsacienne de Constructions Mécaniques for the Paris Orleans Railway, and these are now engaged in regular working on the express services of that line.

The German engine shown is one of twelve built in 1902 for the Baden State Railways. In this design the cylinders are placed in line, with the low-pressure outside and the high-pressure between the frames. Only two sets of valve-gear are employed for actuating the four valves, consequently the cut-off is the same in all the cylinders, and is usually about 40 per cent. of the stroke.

The valve-gear is of the Walschaert pattern, placed outside the wheels, and a rocking-shaft is used for conveying motion to the valves on each side. Those of the high-pressure cylinders are of the piston type, with inside admission, whilst balanced flat valves are employed for the low-pressure cylinders.

A starting-valve is provided, by means of which steam at a pressure of 128 lbs. per sq. in. may be admitted to the low-pressure cylinders direct when exceptional power is required. This valve is operated by means of suitable mechanism connected to the reversing lever and worked from the cab.

The boiler is of exceptional dimensions throughout, and the smoke-box, which is of the very extended type, is fitted with a conical front and contains a spark-arresting device.

The fire-box is of the wide type, as commonly used in America, and the grate area is no less than 42 sq. ft.—an unusual figure for European practice. The front sheet of the cab is formed of two plates brought together at an angle of 90 degs., thus forming a sort of prow, with a view to lessening the wind resistance.

The cranks on either side of the engine are set at an angle of 180 degs. to one another and at 90 degs. to those on the opposite side. This arrangement of cranks renders the use of balance-weights in the wheels unnecessary so far as the reciprocating parts are concerned. Small counterweights are provided for balancing the rotating parts. This practice was largely adopted by Mr. Webb in his four-cylinder engines on the London and North Western Railway, and locomotives balanced in this manner are usually found to be very steady in running at high rates of speed. The engines were designed for hauling trains weighing 200 tons behind the tender, at a speed of 75 mls. per hour on the level and 62 mls. per hour on gradients of 1 in 300. In actual service the train weights vary between 250 and 300 tons, and the scheduled speed is 56 mls. per hour.

Much is claimed for this design by M. Richter, who kindly supplied the photograph, and he characterises the engines as the "most powerful locomotives outside America." The engines were built by the Munich firm of Maffei & Co., at a cost of £4,167 each, a figure at which it is to be feared the majority of railway companies in this country would look askance, even though they did obtain the most powerful engine in Europe in return for it.

Particulars of the respective designs are as follows:

Paris-Orleans Engine.

Cylinders:—	
h.p. (2) outside, $14\frac{5}{16}$ ins.	× $25\frac{5}{16}$-in. stroke.
l.p. (2) inside, $23\frac{1}{2}$,,	
Coupled wheels (diam.) ...	6 ft. $8\frac{5}{16}$ ins.
Boiler (mean diam.)	4 ft. $11\frac{1}{2}$ ins.
,, pressure	228 lbs. per sq. in.
,, No. of tubes (Serve) ..	139
,, Length of tubes ...	14 ft. $5\frac{1}{4}$ ins.
,, Diam. of tubes (inside)	$2\frac{5}{16}$ in.

ONE OF THE NEW 4-4-2 TYPE FOUR-CYLINDER COMPOUND EXPRESS LOCOMOTIVES, PARIS-ORLEANS RAILWAY.

Heating surface of tubes	...	2435·7 sq. ft.
,, ,, ,, firebox	...	181·1 ,,
Total heating surface	...	2616·8 ,,
Grate area	...	33·9 ,,
Weight of engine and tender in running order	...	114·87 tons

Baden State Railways Engine.

Cylinders :—		
h.p. (2) inside, 13·2 ins. / l.p. (2) outside, 22·4 ,,		× 24·4-in. stroke.
Coupled wheels (diam.)	...	6 ft. 10 ins.
Boiler (diam. inside)	...	5 ft. 3 ins.
,, pressure ...	...	288 lbs. per sq. in.
,, No. of tubes ...	...	279
,, diam. ,, (outside).		2 ins.
,, length ,, ...	...	15 ft. 9 ins.
Total heating surface	...	2,550 sq. ft.
Grate area	...	42 sq. ft.
Weight of engine and tender in running order	...	122·7 tons

Private Owner's Railway Wagons.

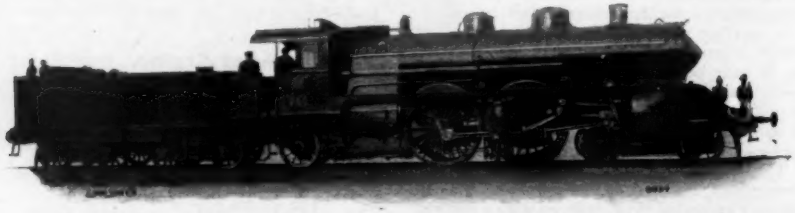
Reference was made to the above subject in the November Notes, and, in accordance with what was then stated, the illustration and description of the standard designs which have been prepared by the Railway Clearing House Wagon Committee, of which Mr. Jas. Holden, locomotive superintendent of the Great Eastern Railway, is chairman, is herewith entered upon.

The construction of a standard 20-ton carrying capacity wagon with wooden body and steel underframing may be followed, and a clear conception of the restrictions which govern its production gathered, by reference to the accompanying drawings, and the extracts from Specifications which are quoted ; thus—

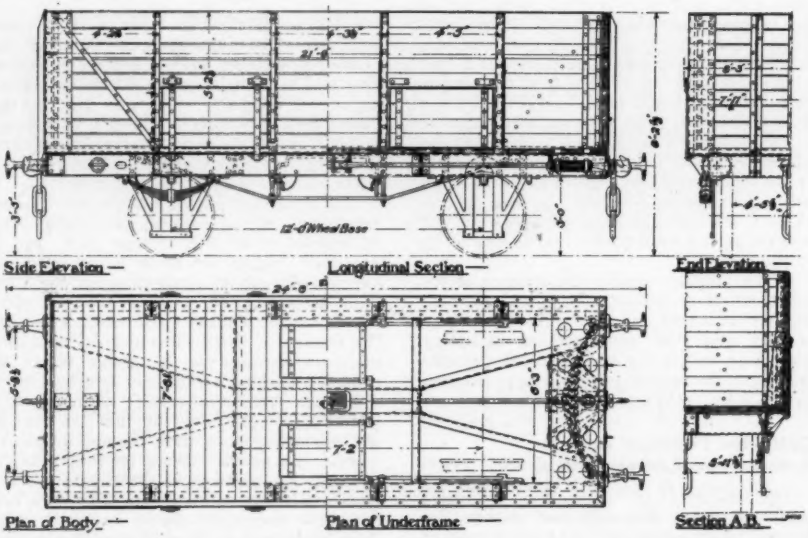
Private owners may build the body of the wagon as best to suit their own requirements, provided they adhere to the dimensions and comply strictly with all the provisions and requirements set forth in the specification. No 20-ton wagon may exceed 21 ft. 6 ins. in length over the body outside, nor exceed 8 ft. 3 ins. in width over all up to a height of 5 ft. above rail level. Above 5 ft. the width may be increased to 8 ft. 6 ins. The height above the top of the rails must not exceed 10 ft. at the sides and 11 ft. 6 ins. in the middle. The wheel base of wagons of 21 ft. 6 ins. in length is to be 12 ft., and for shorter wagons it must be proportionately reduced—10 ft. being the minimum.

The tare must not exceed 8 tons 12 cwts. for 20-ton wagons.

The bodies of the wagons may be made either of wood, iron or steel of approved



4-4-2 TYPE EXPRESS LOCOMOTIVES, BADEN STATE RAILWAY.



STANDARD DESIGN OF 20-TON WAGON PREPARED BY THE "CLEARING-HOUSE WAGON COMMITTEE."

quality, strength, form and dimensions. The underframe to be of steel of approved quality, to the general design shown in the drawing, and capable of withstanding an ultimate tensile strain of not less than 25 or more than 30 tons per square inch with an elongation of not less than 20 per cent. in 8 ins. The steel plates and bars are to be of the quality of material generally known as mild steel, and to contain not less than ·10 per cent. and not more than ·15 per cent. of carbon. All iron plates and bars must be of such quality as to have an ultimate tensile strength of—

	Tons per sq. in.				Elongation.
Round and square bars and flat bars less than 6 ins. wide	22 to 24	with	20	per cent.	in 8 ins.
Angle, tee, channel and H bars, and flat bars over 6 ins. wide ...	21 ,, 23	,,	16	,,	,, 8 ,,
Plates with the fibre	21 ,, 23	,,	14	,,	,, 8 ,,
Plates across the fibre	17 ,, 19	,,	5	,,	,, 8 ,,

Further extracts from the specifications are as follows:

Horizontally hung side-doors when down must clear rail-level by 8½ ins. with the wagon unloaded, and vertically hung doors when open must not extend beyond 6 ft. 6 ins. from the centre of the wagon. The bottom doors of hopper-wagons must, when down and the wagon unloaded, clear the rail level by 7 ins.

Each wagon must be fitted with an improved brake, with brake-blocks of cast-iron and safety loops for preventing the brake-work from falling.

Laminated buffing springs are to be used,

and to admit of bending when cold as follows :--

Thickness in Inches.	Plates to Bend through an Angle of—								
1 in. and 1⅛ in....	15	degs.	with	the	grain,	5	degs.	across	the grain.
⅞ ,, ,, 1⅛ ,, ...	20	,,	,,	,,		5	,,	,,	,,
¾ ,, ,, 1⅛ ,, ...	25	,,	,,	,,		10	,,	,,	,,
⅝ ,, ,, ¾ ,, ...	35	,,	,,	,,		15	,,	,,	,,
7/16 ,, ,, ½ ,, ...	50	,,	,,	,,		20	,,	,,	,,
3/16 ,, ,, ¼ ,, ...	70	,,	,,	,,		30	,,	,,	,,

the buffers to be 18 ins. in length from headstock to face, which is to be 13 ins. diameter; the centres to be 5 ft. 8½ ins. apart and 3 ft. 5 ins. high from top of rails with the wagon unloaded; the buffer-guides must not be less than 10 ins. in length.

All iron work and steel work must be stamped distinctly with the name and initials of the owner, and two register plates must be secured to the sole-bars of the wagons, one at each left-hand corner and 2 ft. from the outside of the headstock; the design to be as shown.

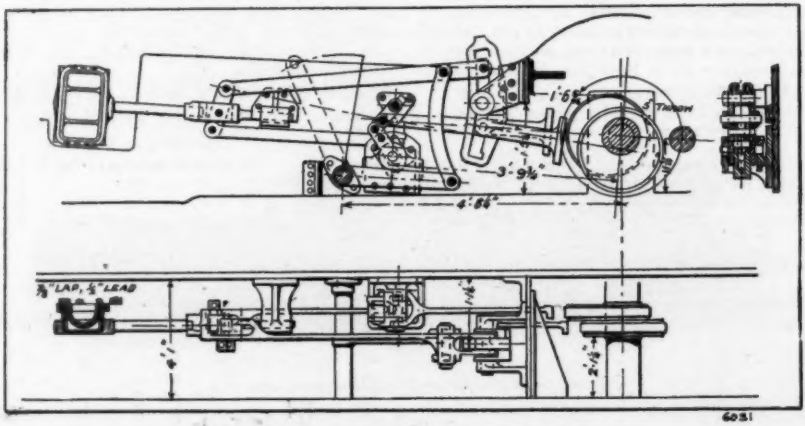
In the January number illustrations of the construction of wheels, axles, springs, etc., will be presented, together with further particulars from the specifications, including some very interesting and instructive matter relating to the various tests and examinations to which the tyres and axles are put.

Cylinder Position on 4-6-0-type Locomotives.

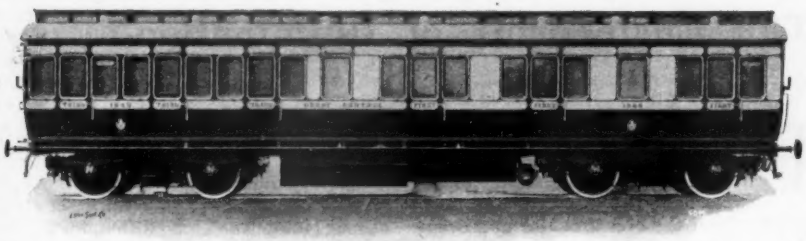
The majority of locomotive engineers prefer to place the cylinders outside the frames when adopting the 4-6-0 type of engine for passenger service, and where the coupled wheels are above 6 ft. in diam. this practice becomes almost imperative, unless features usually held to constitute a disadvantage are to be introduced into the design. The use of six-coupled wheels of 6 ft. 6 ins. diam. and upwards in conjunction with inside cylinders has the effect of increasing the length of the boiler-barrel to a dimension which, in the opinion of many engineers, is an altogether undesirable one. Cylinder proportions necessary at the present day are, it is true, such as demand the presence of large boilers, but an excessive length of tubes does not, unfortunately, mean in practice what it represents on paper, as the gases from the furnace lose a very large percentage of their heat value long before they reach those portions of the tubes which are farthest removed from the firebox. If the cylinders are placed outside the frames, the middle pair of coupled wheels may then be employed as the driving pair, and a moderate length of boiler-barrel and an adequate length of connecting-rod are then both easily obtained. Twenty-inch cylinders can be carried without inconvenience outside the frames of British locomotives, and this diameter appears to be ample under all ordinary working conditions. In the writer's opinion, a further advantage of the outside position is represented by the fact that, as the connecting-rods drive the middle pair of wheels, the power exerted by the cylinders through the medium of these rods is more equally distributed to the coupling-rods, and motion is also more evenly imparted to all the wheels than is the case when the leading pair of coupled wheels are the drivers and the connecting-rods and coupling-rods on either side of the engine are on opposite centres.

An Ingenious Valve Gear.

The writer has been favoured by Mr. John Reikie, a locomotive engineer who has had considerable experience on Indian railways, with a drawing and particulars of the im-



DETAILS OF THE REIKIE-McINTOSH VALVE GEAR.



BOGIE COMPOSITE COACH BUILT BY THE BIRMINGHAM CARRIAGE AND WAGON CO., LTD., FOR THE GREAT CENTRAL RAILWAY.

proved valve-gear which he, in conjunction with Mr. McIntosh, locomotive superintendent of the Caledonian Railway, has patented, and which is at the present time being tried upon the railway in question.

The principal object sought is that of giving the valve a long-dwelling motion when at half-stroke. A separate lever is employed to control the lap and lead of the valve. The short arm of this lever is allowed to slide in a slipper block, so that virtually the effect is to vary the length of the short arm when the piston is at half-stroke. In this way a long dwelling motion is given to the valve, thus allowing the steam to do work on the piston throughout a greater percentage of the stroke, before exhaust takes place, and consequently the exhaust passage on the other side of the piston is kept open later than would otherwise be the case if the dwelling period referred to were not provided. Compression is greatly minimised by this means.

Any delay in the movement of a valve when at half-stroke must necessarily be made good when nearing each end of the stroke, and this results in accelerating the movement of the valve when it is approaching the points of steam admission and exhaust, thus allowing of a l rger port opening, and giving, at the same time, a rapid cut-off when the gear is linked up. A novel feature in the improvement is that the lead can be varied whilst the engine is working. One great advantage which is claimed for this gear is that neither the range of cut-off nor the number of revolutions is limited.

New Coaching Stock on the Great Central Railway.

The writer is enabled, by courtesy of Mr. J. G. Robinson, M. Inst. C.E., Chief Mechanical Superintendent of the Great Central Railway, to illustrate one of the handsome bogie composite coaches which have recently been put into service upon this railway.

As will be noticed this stock is provided with the clerestory pattern roof, and is divided into six compartments, three being First and three Third-class. The latter are connected by corridor with a lavatory, whilst each First-class compartment is provided with its own lavatory accommodation. The carriages have steel underframes and bogies. They are lighted throughout by electricity and will accommodate 15 First and 25 Third-class passengers.

Some of these coaches have been so designed that four First-class passengers in each carriage can be provided with sleeping accommodation. The general external appearance and comfort of the interior appointments leave nothing to be desired.

The builders are the Birmingham Railway Carriage and Wagon Co., Ltd..

CHAS. S. LAKE.

Errata.

The writer regrets that in speaking of the locomotive performance on the Great Central Railway in the November number, engine No. 1015 was referred to as No. 2015, and that the engines of Mr. Drummond's design on the South-Western Railway were spoken of as having 7 ft. 7 in. wheels instead of 6 ft. 7 ins. Both were printer's errors.

The Engineering of Illumination.

(Continued from page 448.)

PLAN No. 2 consisted of a good general diffused illumination with use of special desk lights, which were intended to cut off the glare directly from the eyes and also to prevent the shadows and streaks as well as the regular reflection resulting from the ordinary reflector. Upon taking these conditions into account it was finally decided to use the present outlets, placing eight 16-in. Holophane hemispheres on the ceiling enclosing four 32-candle-power lamps, thus removing the glare and giving a good general illumination. As before pointed out, the chief objection to the ordinary green reflector is that it casts streaks over the paper which are extremely trying to the eyes. In order to do away with this, it was decided to use a green porcelain reflector so designed as to admit of a very small Holophane globe within, for the purpose of taking away not only these streaks but also the glare due to regular reflection which accompanies the use of the ordinary reflector. The same results could have been obtained by using the McFadden or McCreary shades, but at a slight decrease in efficiency, the initial cost of these shades being about the same.

A problem which differs materially from either of the above plans was that of lighting the Sculpture Hall of the Art Institute of Chicago. The plan and elevation of this room are shown in Fig. 14. The problem here was not to light the horizontal, but rather the vertical, as the room was to be used almost entirely for large sculptural pieces. The height of the lights was governed by the fact that along one side of the room was a balcony, by which people entered, and it was not desirable to lower the lights below the spectator's eyes, as many of the sculptural pieces were considerably higher than the balcony, and the effect of trying to see beyond the lights, as is well known, would be extremely unsatisfactory. The location of the lights was also somewhat governed by the fact that the ceiling was panelled, and for artistic reasons it was impossible to place the lights anywhere except in the centre of the panels and on the beams. As the walls and ceiling were white, and as most of the casts would also be of the same colour, it was decided that about 1 candle-power per 50 cub. ft.

FIG. 132.—SPECIAL FORM OF DECORATIVE LIGHTING USED AT THE MILWAUKEE EXPOSITION.

would be sufficient illumination. As shown previously, the distribution curve would have to be laid out in accordance with the formula for vertical illumination formerly given. In this way the value of the illumination at different points, and at different heights on the walls, and on imaginary vertical planes, running parallel and at right angles to the length of the room, was obtained, and the lights were so placed as to give the best effect, taking into consideration the fact that there would be considerable reflection from the walls and statuary, and that this reflection would be more intense near the sides of the walls than in the centre. The original plans of using Holophane spheres was finally postponed and arc lights substituted, on account of the fact that the company supplying the current would furnish the arcs free of cost. It is intended, however, to replace these arcs by the original lighting scheme for which the plans were designed.

A paper of this length does not permit of a further consideration of the distribution question. The general principles laid down here are applicable in most cases. The question of house lighting, however, is not as complex as those considered. In general, it is not advisable in such cases to have a uniform illumination. It is better to use a good general illumination, and where the light is wanted in some particular place to supplement this by some special light, such as a lamp or candle. The lighting of theatres, churches, and other such buildings presents special problems which must be worked out in detail, always remembering that the artistic must not be sacrificed to the practical.

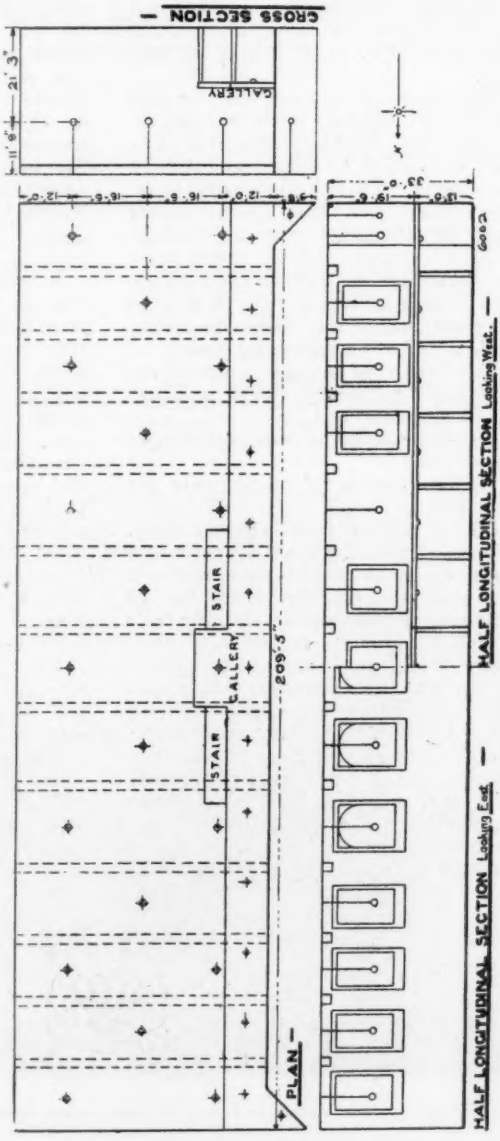


FIG. 14.—ILLUMINATING PLAN OF SCULPTURE HALL, CHICAGO ART INSTITUTE.

Quantity of Light.

In laying out the lighting for any purpose it is first necessary to determine—at least approximately—the quantity of light to be used. The approximation can later be revised after calculations are made, in case too much or too little light has been used.

The amount of light necessary for good illumination depends upon the purpose for which the place to be lighted is to be used, and also on the individual's ideas on the subject. Thus the requirements for street, house, and office lighting present great differences. Further, the amount of light necessary depends largely upon the character of the surrounding surfaces, such as walls, ceiling, etc., as well as upon the absorption of the shades, if such are used, as well as their directing power.

There are three methods in general use by which the quantity of light necessary can be approximated:

(1) The number of candle-power per square foot;

(2) The number of candle-power per cubic foot;

(3) The number of candle-feet necessary.

The best practice, where actual work is concerned, is to use all three methods. The amount of light per square foot, as before noted, varies widely—in some cases as high as 1 candle-power per sq. ft. where a very strong light is desired; and, again, as low as 1 candle-power per 5 sq. ft. in a large room, where simply a general illumination is required. The mean of these two, or about 1 candle-power per 3 sq. ft., when the reflection factor is about 50 per cent., is a good working basis for ordinary illumination. For the cubic-foot basis the height of the lights from the ceiling plays an extremely important part. In practice, however, it is safe to allow 1 candle-power for from 25 to 50 cub. ft. The latter is sufficient in places where the walls are of light colour, but where dark would not be satisfactory. Under the third method $\frac{5}{10}$ of a horizontal candle-foot will give a fair illumination. For reading purposes this should be raised to a minimum of 1 candle-foot, and for lighting desks, etc., this should be increased to about 2 or $2\frac{1}{2}$ for best results. The writer would like to call attention to some valuable data on this subject, which checks up very closely with his own experience, in Dr. Louis Bell's recent book entitled "The Art of Illumination."

It is highly desirable to obtain data on this and other kindred subjects relative to illumination, and the writer hopes at a later date to be able to present a table giving the results of a large number of installations, which will include such data as the number of candle-power per square foot, candle-power per cubic foot, the character of the walls, ceiling, decorations, the nature of the illuminant used, the kinds of shades used, the method of distributing the light, and other points. If such data as this were collected by engineers who are engaged in this kind of work, and the same could be tabulated, it would be a most valuable contribution to the literature of the subject.

Fig. 13a shows a special form of decorative lighting designed by Messrs. Clas and Rau, and used at the Milwaukee exposition. The picture shows about half of the hall with festoons of incandescent lights enclosed in Holophane globes, and with red paper shades. There are also some No. 3 Glower "Nernst" lamps used in the centre with Holophane globes. The lighting effect was very satisfactory.

MARINE ENGINEERING & SHIPBUILDING NOTES.

North-East Coast.

THE engineering and shipbuilding industry on the north-east coast, as is the case more or less generally, is passing through a time of decided depression. The abnormal demand for tonnage, which caused a remarkable degree of prosperity during the past few years in the district, has been more than supplied. Freights have dropped, whilst working expenses in the vast majority of instances remain as before. At the time of writing notices of reductions have been given to the representatives of the Boilermakers' and Iron and Steel Shipbuilders' Society on the Tyne, Wear, and Tees, of 5 per cent. on piece prices and 1*s.* 6*d.* per week on time wages. It is to be sincerely hoped that terms, mutually satisfactory to employers and employed, may be arrived at without recourse to the drastic system of strikes or lockouts.

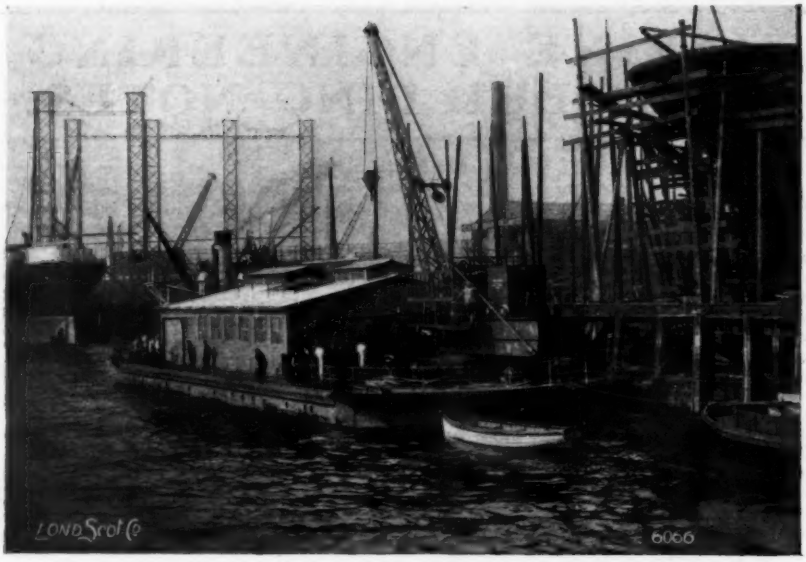
* *

A number of new shipbuilding orders have been given out recently, including a considerable amount of Admiralty work; but owing to the work in hand rapidly approaching completion, the effect is merely to fill up a few of the berths thus rendered vacant.

* *

Apart from conditions of trade, this year has been a most interesting one in the maritime world. It has marked the commencement of a new era in steamship propulsion.

FLOATING DOCK, CONSTRUCTED BY MESSRS. SWAN HUNTER AND WIGHAM RICHARDSON AND CO. TO REPLACE THE ONE LOST ON THE PASSAGE OUT TO DURBAN.



FLOATING WORKSHOP FOR DURBAN HARBOUR, CONSTRUCTED BY MESSRS. SWAN HUNTER AND WIGHAM RICHARDSON AND CO.

The Tyne, famous for many inventions, has again come to the forefront as the birthplace of a new method in the system of propelling ships. The Parsons steam turbine, which has already achieved such undisputed success in many classes of vessels, has come to be looked upon as the engine of the future. The Company's works at Wallsend-on-Tyne have in hand a large amount of work for varied types of vessels.

Distinct success has attended the introduction of this type of engine in torpedo-boat destroyers. The *Velox*, built by Hawthorne, Leslie & Co., Hebburn-on-Tyne, attained a maximum speed of 33¾ knots per hour on trial. The first war vessel, other than torpedo-boat destroyers, to be engined on this principle is the *Amethyst*, which was launched at Elswick on Nov. 5. Her contract speed is 21¾ knots. A cross-channel steamer being built by Denny Bros., of Dumbarton, for the Larne and Stranraer service, has also to be fitted with turbines. In addition, two 20-knot passenger ships are being built for the Midland Railway Company's new service between Heysham and Belfast. Perhaps more interest than ever centres itself round the new ocean ships being built for the Allan line, and the Union Steamship Co. of Tasmania, as these boats will demonstrate the utility of the turbine for large ocean-going steamships of moderate speed. The largest boat under construction is the Allan liner *Victorian*, which is 12,000 tons gross register, and is to steam between 16½ and 17 knots. The opinion of the Commission appointed to inquire into the suitability of the turbine for the new Cunarders is being awaited with great interest.

* *

Important experiments have recently been carried out at the Wallsend Slipway and Engineering Co., Wallsend-on-Tyne, with the Körting system of burning oil fuel. The fuel is sprayed directly into the furnace through a Körting sprayer by means of a pump. The experiments, which were conducted in the presence of an influential company, showed that an evaporation of over 16 lbs. of water from and at 212 degs. Fahr. was obtained per lb. of fuel consumed. The company have fitted over 80 vessels with oil-burning apparatus, some of the most recent being on this system. We hope to publish further particulars in next month's issue.

* *

Messrs. Swan Hunter & Wigham Richardson & Co. have recently turned out two interesting types of floating structures, of which illustrations appear herewith. The floating dock was built to replace the one which was unfortunately lost on the passage out to Durban. The principal dimensions are: length 475 ft., width 96 ft. 2 in. It is capable of taking ships up to 68 ft. beam, and has a lifting power of 8,500 tons; and whilst retaining a freeboard of 4 ft. 3 ins., can take a vessel drawing 23 ft. over keel blocks 4 ft. high. The dock proper consists of three pontoons and two side walls, and is so arranged as to be self-docking. The machinery is contained in the upper portion of the side-walls, and consists of two separate but identical installations. The boilers are of the ordinary return tube marine type, 10 ft. long by 8 ft. 6 ins. diam., by Messrs. Cochrane & Co., of Annan. The engines are horizontal-compound, connected directly to the centrifugal pumps, which are placed at the bottom of the dock, directly on top of the main drain of the pumping system. They are built by Messrs. Drysdale, of Glasgow. There are 44 separate water-tight compartments, with a separate pipe leading into each. In addition to the main pumping service, there is a small direct-acting drainage service into all the pontoon compartments, which can also be utilised, by changing nozzles, as a washing-down service for cleaning the sides of vessels, or for filling tanks for testing purposes. The pumps for this service were made by Messrs. Lamont & Co., of Paisley. The erection of the machinery, generally, was carried out by the Wallsend Slipway & Engineering Co. The fittings consist of the usual keel blocks and additional sliding bilge blocks, four mechanical shores, four steam warping winches, and numerous bollards and timber heads. In addition to the ordinary requirements, the dock has a very complete electric light installation to enable work to be carried out through all hours of the day and night. This installation, which is placed in one of the side walls, consists of a marine-type boiler by Clarke, Chapman & Co., Gateshead-on-Tyne, and two separate and identical steam dynamos. Sufficient power is provided to enable electric drills and other machines to be taken from the plug boxes, for carrying out work on the hulls of ships in the dock.

* *

The floating workshop for the harbour of Durban has been constructed to meet the requirements of steamers and other vessels, and, being self-propelling, can, if so desired, steam direct to such vessels with a view to executing repairs, etc. The propelling machinery is by Messrs. Baird & Bros., of North Shields. The boiler is of the marine type, and works at 130 lbs. pressure. The engines are twin-compound vertical direct-acting, with cylinders 12 by 26 by 15 in. stroke. The large crane, useful generally as regards repair work, is also capable of dealing with any transport or lifting work in or about the harbour; indeed, under ordinary conditions of weather, the vessel can conduct operations outside the harbour.

The shop machinery consists of a complete installation of machines necessary for repair work, comprising a screw-cutting lathe, shaping machine, drilling and tapping machine, improved double-geared radial drilling machine, 30-cwt. steam hammer and punching and shearing machine for plates and bars; in addition to which are the accessories necessary for repair work. The electric generating plant consists of a six-pole dynamo capable of giving out 300 ampères 110 volts at a speed of 320 revolutions per minute, and is driven direct by a Robey compound engine $\frac{8\frac{1}{2} \times 4\frac{1}{2}}{9}$ with all the necessary switch-boards, etc. Accommodation is provided for a crew of six Europeans and ten natives, with all necessary galleys, stores, etc. The bunker capacity is 38 tons, and there are tanks to hold 18 to 20 tons of fresh water for feed purposes, in addition to separate tanks for drinking water.

* *

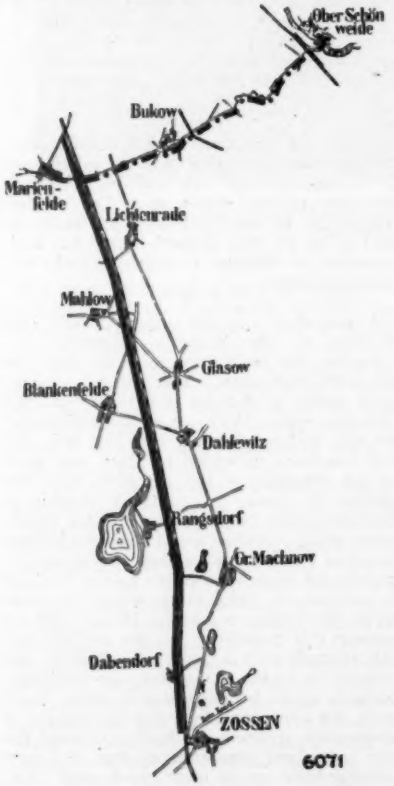
A propeller, recently patented by Capt. Walters, of the Walter's Propeller Co., Liverpool, has been fitted to some ships on the north-east coast. The general appearance bears a distinct difference to the orthodox type. With a view to minimising the loss due to churning near the hub, the hub has been increased to about one-third of the diameter of the propeller, and the blades, in order to develop maximum efficiency, have been given a greater differential pitch. In the case of old ships having this type fitted, it is necessary to fit a circular diaphragm plate on the fore side of the hub to prevent any drag on the water. In new ships the frames would be swelled out to answer this purpose. A cone is fitted on the afterside with a wood tail bolted to the rudder, in order to obviate any eddying. Reports made by engineers of ships fitted with this apparatus show that an increase of about three-quarters of a knot is attained for the same coal consumption, and in heavy weather have proved most satisfactory. Examinations conducted by engineer surveyors have proved that no appreciable wear is brought to bear on the tail-end shaft.

The Marienfelde-Zossen High-Speed Trials.*

IN connection with the announcement given by the daily papers of the successful results recently obtained with the Marienfelde-Zossen high-speed trials, it will be of interest here to record some particulars as to these experiments.

As far back as 1900 Messrs. Siemens & Halske installed a small trial-railway at Gross-Lichterfelde, near Berlin, intended to be a model normal railway for operation by currents at 10,000 volts. It is due to the enterprising mind of some of the most important German banking and technical firms, as well as to the assistance of the authorities concerned, that in 1901 it was decided to construct a high-speed railway after the model of the Gross-Lichterfelde experimental track, a special concern for this purpose being founded under the title of "Studiengesellschaft für elektrische Schnellfahrten." Two cars, built respectively by the Siemens Company and the Allgemeine Elektricitäts Ges., were to be used in the experiments, which had for their object the determination of practical limits and conditions of high-speed electric traction. The Siemens & Halske Co. undertook the construction of the overhead line, whereas the Allgemeine Elektricitäts Ges. were willing to generate the electric power in their Oberschönweide electricity works, as well as to construct the feeding line thence to Marienfelde.

* Readers should refer to a previous article, compiled from data furnished by Messrs. Siemens & Halske, that appeared in Vol. 8, No. 2 of FEILDEN'S MAGAZINE.



MAP OF THE MARIENFELDE-ZOSSEN MILITARY RAILWAY.

The conditions of the problem to be solved were as follows :—

1. The single-track Marienfelde-Zossen military railway near Berlin, 23 km. in length, was to be used. This line includes gradients up to 1 in 184, the smallest radius of curvature being 1,000 m. The line is standard gauge and the rails are supported by wooden sleepers.

2. The capacity of the car to be for about 50 persons, and to conform to the loading gauge of the Prussian Railway.

3. Two standard gauge trucks, with three axles each, were to be provided for a maximum load of 16 tons per axle, including the weight of passengers.

4. The electric power was to be supplied in the form of three-phase alternating current at about 10,000 volts and 45 to 50 periods per sec.

5. The steering and control of the motors, the application of collectors, and the insertion of any apparatus to be possible from either end of the car.

6. The maximum speed to be 200 to 220 km. (125 to 138 mls.) per hour, the electric equipment being strong enough to avoid any excessive heating effect, when traversing a track 250 km. (155 mls.) in length, in both directions.

7. The starting and braking distances to

be determined, so as to allow of sufficient time for observing the consumption of power at full speed. The length of the observation section was determined at 10 km., the time-equivalent being about 3 mins. ; two independent brakes, one mechanical and one electrical, to be provided.

8. An accumulator battery might be used in connection with the electric lighting of the car.

The Consumption of Power.

It was naturally anticipated that the air resistance would represent the main part of the total resistance to be overcome. As, however, the formulæ so far used to calculate the total resistance would give too high a value, it was thought advisable to separate the air and friction resistances. The latter is made up of the resistance of sliding and rolling friction, and of the resistance due to the shocks at the joints, as well as to the deflection of the rails. The latter is generally assumed to be equal to 2·5 kg. per ton ; and when taking, for safety's sake, a value as high as 4·5 kg. per ton for this item, the tractive force necessary to overcome this resistance on the periphery of the running wheel is

$Pr = G \times Wr = 96 \times 4{\cdot}5 =$ about 450 kg.

Now, as the values obtained by this formula were also too high, it was necessary to diminish the friction constant by constructive means. Special experiments showed a bevelling of the carriage surface to be very effective in this connection, the resistance now taking convenient values. At a speed as high as 55 m. per sec. the total work performed by the carriages, as measured on the periphery of the running wheel, worked out at about 1,000 h.p.

General Design of the Carriage.

The following distribution of the various units was decided on :—

1. The *mechanical equipment*, comprising the trucks, wheels, brakes, and accessories was placed at a total of 27,300 kg., the body and remaining mechanical equipment of the car working out to a total of 27,700 kg.

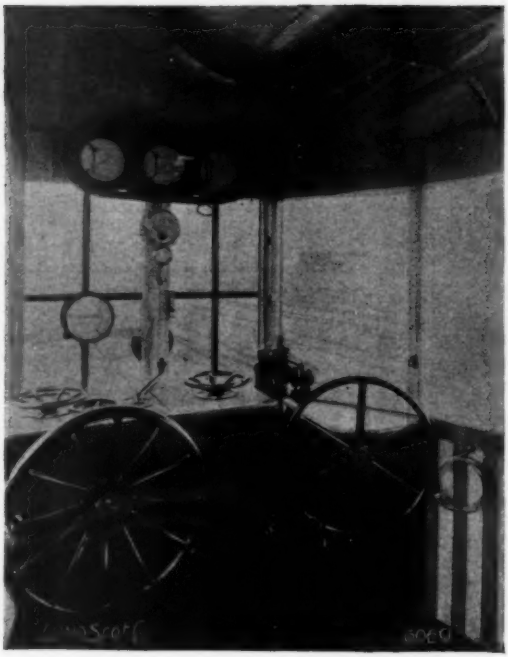
VIEW SHOWING THE TRACK AND THE ARRANGEMENT OF THE OVERHEAD WIRES.

2. The *electric equipment*, made up of the following items :—

	Kg.
Motors without axles and wheels, including suspension	16,300
Resistances, including exciters ...	5,100
Switching apparatus, including compressed-air exciter, electric distribution line, fuses, etc. ...	4,700
Large transformers, including suspension	12,300
Air pumps, including suspension	1,000
Small transformers for the latter	650
Collectors	1,300
Lighting, including battery ...	500
	41,900
Including the weight of 50 persons and allowing for a safety factor, the total weight reached ...	94,500

The Electric Equipment of the Cars.

In order to ensure perfect safety of both



MOTOR-MAN'S CAB: SIEMENS AND HALSKE CAR.

passengers and the staff, all the apparatus and conductors were arranged below the floor or on the ceiling of the car, both being protected by grounded metal sheets; moreover, instead of the controlling apparatus being actuated immediately from the hand of the motor-man, a compressed air installation was provided for this purpose. The various units constituting the electric apparatus of the car had to be arranged so as to distribute the weight uniformly, instead of concentrating the same on one point, this ensuring at the same time a ready dissipation of the heat generated by the different losses in power. The electric equipment was accordingly divided into two units, each of which comprised:

1. Two motors with two sets of resistances, and two exciters, two switches, and two fuses.

2. Two large transformers with secondary triangular and star switches, as well as primary high-tension switches and high-tension fuses.

3. One air pump with small transformer fuses, and one air reservoir.

4. One collector.

5. One motor-man's stand, including the compressed-air apparatus and the measuring instruments.

The running wheels are 1,250 mm. in diameter, and the rate of revolution is sufficiently high as to make an immediate mounting of the motors on the axles possible. There are four motors—two to each truck—of 250 h.p., constructed, however, with an overload capacity of 200 per cent. at starting. In order to avoid any excessive currents, the primary pressure at the motors was taken at 1,150 volts for full speed and at 1,850 volts for starting. The motors are controlled in starting by resistances inserted into the secondary of the motor: the latter has, at starting, a tension of about 550 volts.

The Overhead Line.

The arrangement of the overhead wire is shown by the accompanying figures, the middle of the poles being about 2½ m. distant from the centre of the track, and the three horizontal wires being about 1 m. apart. The suspension point of the lowest horizontal line is about 1½ m. above the upper edge of the rail. The whole of the line is divided into sections of about 1 km., each of which is provided in the centre with a device for compensating losses in tension. The zero of the system is connected to earth and to the rails. The suspension point is horizontally displaced to a certain extent as soon as the collector presses against the horizontal wire, a satisfactory and simultaneous contact between the three horizontal wires and the contact bows being thus possible. This is ensured by the single parts on the outrigger, intended for bearing the insulator, being connected by articulations. The horizontal wires have a double insulation, each alone being susceptible of withstanding the whole of the maximum pressure of 20,000 volts occurring during the service. The three horizontal wires have cross sections of 100 sq m. each, the tension between each two wires varying between 10,000 and 12,000 volts. Hard copper wire,

with a breaking strength as high as 38 kg. per sq. mm. and a conductivity of at least 97 per cent. of that of chemically pure copper, is used. Lightning rods are provided as well as safety devices for automatically putting the wire to earth in case of a fracture occurring.

The Collectors.

The collectors in the Siemens car are in the form of masts and are movable round their vertical axis. They are built up of two Mannesmann tubes, about 200 mm. in diameter, inserted one in the other. By means of a crank acting on a double-toothed gearing, any desired rotation of the mast may be effected from the motor-man's stand. The sliding rings are attached to the upper insulated tube. Contact springs, screwed by means of hard rubber insulators to a special flat-iron frame, are fixed to the three sliding rings. Into the insulating tube, and partly into the lower part of the collector, the upper tube is slipped, so as to be readily dismounted after loosening some screws. This tube bears, at central distances of 1 m. each, three rotating axles for the contact bows proper. The wind pressure against the bow on one side of the rotating axle is outbalanced by means of a surface attached to the other side of the axle. In the Allgemeine Elektricitäts Ges. car the arrangement is quite similar but for the contact bows being mounted behind one another. The Siemens and Allgemeine Elektricitäts Ges. cars are little different as to their exterior form but for the former being one meter longer and somewhat narrower than the latter. These small differences are, however, likely to give interesting results as to the influence of the design on the air resistance of the car, this resistance increasing most rapidly for augmenting speeds, and eventually consuming by far the greater part of the energy. As regards the electric equipment, there are more essential differences, the four motors driving the Siemens car being mounted rigidly on the axle, whereas in the Allgemeine Elektricitäts Ges. car they are placed on springs in a frame fixed on the axle-box. The resistances necessary in starting are in the Siemens and Halske car made of metal, being operated through a controlling roller driven by compressed air. With the Allgemeine Elektricitäts Ges. car, on the other hand, starting is attained through a novel form of liquid resistances, allowing the output to be accurately regulated and an

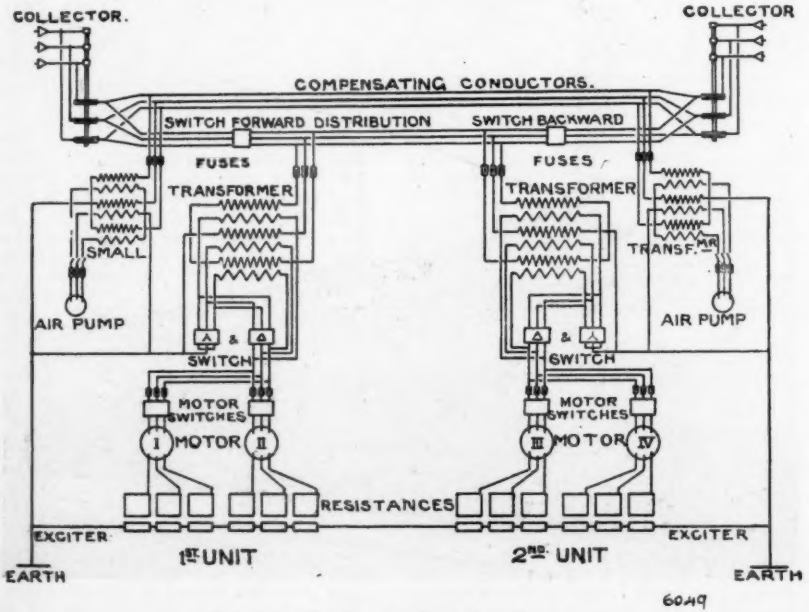


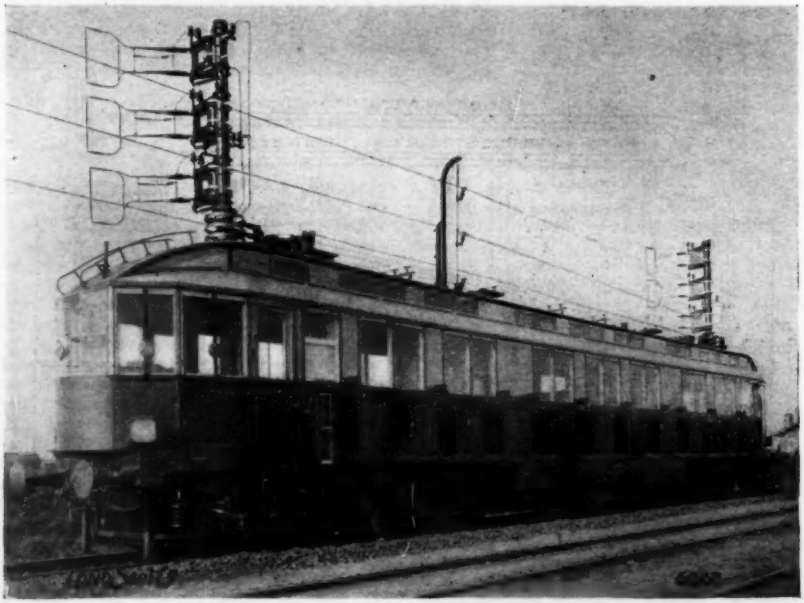
DIAGRAM OF CONNECTIONS: SIEMENS AND HALSKE CAR.

excessive heating of the resistance made impossible. The steering of this apparatus is affected from the motor-man's cab through a simple mechanical gearing.

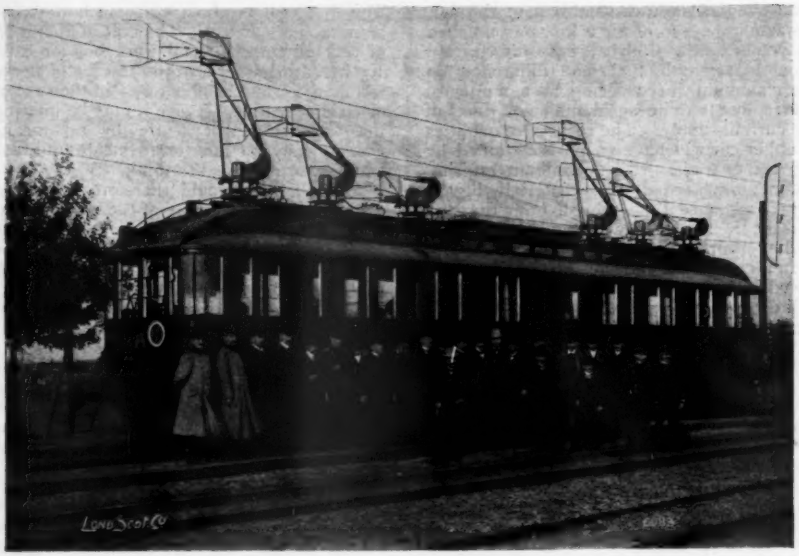
The permanent way was originally ballasted with gravel ; the latter, however, was eventually replaced by a bed of finely-pounded basalt before this year's experiments were entered upon.

The experiments made in the course of 1901 and 1902 allowed of speeds as high as 150 to 160 km. being reached. As, however, considerable oscillation and shocks were experienced by the car even with these speeds, in addition to deflections of the rails and cracks in the sleepers taking place, it was thought advisable to reconstruct the track, the specification adopted being the heavy permanent way used in connection with Prussian state railways. Special safety devices against derailments were provided, made up of two horizontal rails placed 50 mm. above the running surface. As far, however, as experiments were made, these sliding rails were never operative, thus showing the usual type of permanent ways to be fully suitable even for speeds as high as 200 km. In addition to the rails the design of trucks was revised, the distance of the wheels being increased from 3·5 m. to 5 m., the pivot being made capable of taking up lateral movements, and the frames covering part of the springs being replaced by a design which permitted a ready inspection of these parts. By the use of compensating levers similar to those used in connection with locomotives, a uniform distribution of the weight of the car over the various wheels was ensured. Excellent results attended these modifications, the cars running now at the prescribed maximum speeds as steadily as in the case of speeds of about 130 or 140 km. The distribution line had also to be modified in order to avoid fractures and short circuits, which formerly occurred occasionally. This was ensured by adopting lighter contact bows, fitted with better springs, as well as by some alterations of the overhead wire itself being made.

The experiments made in the course of 1901–2 had shown the electric equipment and the distribution line to give excellent results for speeds up to 160 km. per hour. The above-mentioned modification of the



THE SIEMENS AND HALSKE CAR.



THE ALLGEMEINE ELEKTRICITÄTS GESELLSCHAFT CAR.

experimental railway occupied part of the year 1902, the remainder of which was taken up by experiments on the consumption of energy, etc., for speeds up to 130 km. The results of the improvements made were shown in connection with the recent trials to be most satisfactory and even surprising. The track not only fully withstands the strain to which it is put by trials with ever-increasing speed, but the cars now run with a steadiness such as to reduce shock to the rails to a minimum. It is, for instance, possible for an inspector to write down the readings of the measuring instruments when standing in the middle of the car even at full speed.

After reaching speeds as high as 189 km. per hour at the end of Sept. last, it was anticipated that the resumption of the experiments at the beginning of October would lead to the maximum speed of 200 km. being finally arrived at. This was actually the case on October 6th, the event being watched by a great number of lookers-on. In fact, the morning suburban trains leaving the Potsdamer Platz Ringbahn station, at Berlin, were filled both with engineers and the public anxious to attend the trials, and going to one or another of the trial railway stations, if they were not to take a part in the trials, this being a privilege of only a few. The distance between Marienfelde and Zossen, being 23 km. in length, was repeatedly traversed in not more than 8 mins., including starting and pulling up; the maximum speed of 201 km. (126 mls.) being actually reached on the Mahlow-Dahlwitz-Rangsdorff section of 5 km., traversed throughout in 1½ mins. The mean speed of 175 km. per hour., including braking and starting, would enable the journey between Berlin and Cologne (577 km.) to be completed in about 3¼ hrs., whereas the quickest present trains take fully 9 hrs.

The great success of October 6th has even been surpassed by the experiments made in the course of the subsequent weeks. On one hand, the Siemens car, which first was allowed to prove its possibilities, reached speeds as high as 207 km. per hour on October 23rd on a gradient of 1 : 200, corresponding with 210 km. on the horizontal line. On the other hand, the Allgemeine Elektricitäts Ges. car, commencing the trials only after the 200 km. record run of its rival, has rapidly made up for the delay occasioned by some reconstructions. Commencing with moderate speeds of about 150 km., so as to

ascertain the working condition of the car, a maximum speed of 210·2 km. was reached on October 28th. Both cars have thus proved equal in strength, the small differences in the maximum speeds being, as a matter of course, due to quite accidental conditions of the current supply. The respective qualities of either car will have to be ascertained by the further trials. It is not intended raising the maximum speed to any materially higher figures for some time, though both the cars and the track are likely to stand considerably higher strains.

In a car running at such exceedingly high speeds, the neighbouring objects, of course, will disappear from view. Though the motorman would be able to distinguish obstacles on the track, this would be of little use, the braking distance—*i.e.* the distance from the beginning of braking to the stopping of the train—being 2 km. Lookers-on could just distinguish the presence of men in the car; before, however, being able to fix their figures the car had absolutely disappeared from view. Though the track is very straight, 30 seconds at the most elapsed between the first appearance of the car and its disappearance on the horizon.

The difference between electric and steam operation of railways from an economical point of view is shown by the following calculations made by Dr. Reichel. A steam railway train, comprising a steam locomotive and six carriages, weighs, say, 330,000 kg., contains 168 seats, and consumes 1,400 h.p. at full speed. On the other hand an electric train, consisting of one motor-car and four trailers, would have a weight of 260,000 kg., contain 180 seats, and consume 1,000 h.p. The first cost is about equal in both cases, being about £20,000. The cost of operation of the train itself would work out for each 100 km. at 6½*d.* per seat in the case of steam locomotives, and at about 6¼*d.* in the case of electric operation. Hence it may be inferred that electric railways are by no means economically so inferior to steam railways as many are inclined to think.

These figures would therefore appear to evidence the justifiability of the employment of capital for the construction of electric high-speed railways, provided always the traffic was sufficient to warrant the economy of the enterprise. Anyhow, the Marienfelde-Zossen experiments have shown the practicability of speeds as high as 200 km. per hour, and this, no doubt, will not fail to have some influence on the future development of railways in general. The limits of speed capable of being reached with the present system is particularly coincident with the above figure; in fact, in spite of the most careful design of the collectors, the contact of the overhead wire begins to lose in safety at speeds of 200 km., especially at curves, where the overhead wire has a polygonal form. On the other hand, the consumption of power, stated at 1,600 h.p., is so considerable as to make such high speeds inadvisable. Dr. Reichel therefore suggests choosing at the present moment maximum speeds of 160 to 170 km. which may be maintained with perfect safety.

My thanks are due to the Siemens & Halske Co. and to the Allgemeine, to whose courtesy I am indebted for part of the data here given, and who also kindly supplied the photographs.

A. G.

It has been represented to us from time to time by numerous readers and advertisers that the title at present borne by this Journal does not adequately describe its position in the literature of technology, nor does it indicate the thoroughly technical character of its contents.

It has been decided therefore that commencing with the JANUARY Number of 1904, the title will be altered to

The Engineering Review,

formerly

Feilden's Magazine.

TOPICS OF THE MONTH.

The Presidential Address to the Institution of Electrical Engineers.

THE Presidential Address delivered by Mr. R. Kaye Gray at the first meeting of the session of the Institution of Electrical Engineers is not likely to occasion such an embittered controversy as that which followed the address of Mr. Swinburne on a similar occasion a year ago, but it contains several suggestive ideas which are worthy of attention. The main portion of the address was devoted to a summary of recent progress in the different departments of electrical engineering, and it shows that in every direction the application of electricity to technical industries is becoming more extensive, and the demand for electric power and lighting is steadily on the increase. The statistics given by Mr. Gray are interesting and useful, as they cover many diverse subjects, for information on which one has usually to search far and wide. This portion of the address, however, does not call for discussion, as it is almost purely confined to statements of fact, on which difference of opinion is hardly possible. But in one or two places in the course of his address Mr. Gray has dealt with ideas as distinct from facts, and with questions of policy about which opinions may, and do, differ much; and as contradiction is always a strong force in human nature, we should not be surprised if the attention of the public becomes fixed on these argumentative sections to such an extent that the historical portion may be entirely overlooked.

The first point to which attention may be drawn is the reference to the proposed introduction of the decimal system to replace our present system of weights and measures. Against this proposal Mr. Gray desires to protest, but his is not an unreasoning opposition. There can be no doubt that in many branches of scientific work the use of the decimal system is an enormous advantage, and, indeed, practically a necessity, as our English units prove quite unworkable. This Mr. Gray is ready to admit; he agrees that to have a common relation between the various units in such subjects as physics and chemistry is a great gain, but he is not prepared to step at once from the particular to the universal and to say that the system could with the same advantage be brought into common use to the exclusion of all others. He scores distinctly when he points out that even France, the country of origin of the decimal system, has almost as many different units in use in common life as we have:—

> "In France, precious stones are to-day bought and sold in carats; firewood in cordes; milk in pintes; gravel in toises; grain, potatos, and charcoal in boisseaux; wine in barriques, feuillettes, demi-setiers, and chopines; wood for construction in pieds, pouces, and lignes; beer in canettes and pots; sugar and coffee among the poor people are dealt with in livres, demi-livres, etc. Cattle dealing is carried on in pistoles and écus, and not in francs. Finally, they have just issued a 25-centime piece, doubtless because it represents a quarter of a franc."

This tends to support Mr. Gray's view that the decimal system, applied to weights, measures, and money, offers too limited a field for the operations of ordinary life. Our system certainly has disadvantages, but it has one great advantage. With a system in which 12 is the unit, it is possible to have both fourths and thirds as perfectly definite quantities, whereas on the decimal system thirds lead to recurring decimals. There is, however, room for both systems—both are now legal—and where firms are dealing with foreign countries they ought to consider the advis-

ability of quoting dimensions, weights, and prices in catalogues and trade circulars in decimal as well as in the English system. We believe Mr. Gray would agree with us in this view; what he protests against is the idea of legislating to enforce the decimal system to the exclusion of others, and there is much to be said for his view.

The only other point in the address which we can at present find space to mention is the president's reference to the "foreign invasion," and the need for technical education. Mr. Gray is not an alarmist on this subject. He takes the very sane view that we help ourselves by welcoming in our midst the skilled men of other countries, using them to maintain supremacy in some of our productions; but he would prefer that we should have countrymen of our own of equal education and skill to do the work now given to foreigners. The electrical industry, as Mr. Gray points out, does not suffer much in this matter, as the large majority of our electrical engineers have been born and educated in this country; but the chemical industry affords a striking illustration of the evil indicated. Indeed, through lack of enterprise, that industry was allowed to pass away to a very large extent, although in many cases the raw material for the industry is supplied from this country, as in the case of the coal-tar dyes. There is no reason why, since we have the raw material and also make large use of the finished dyes, the manufacture of these dyes should not be done here instead of abroad. Lack of enterprise began the mischief, and lack of a sufficient number of highly-trained scientific chemists completed it. There is an improvement now, but there is still room for further improvement in the facilities for proper instruction. If in the electrical and other industries we have cause for complaint that our manufacturers are handicapped in the competition for foreign markets, let us at least take care that at home we are not, in the words of Mr. Gray, "beaten in the race in which the foreigner is handicapped." This is a point which has been somewhat overlooked, and Mr. Gray has done good service in bringing it out so clearly.

British Imports.

Not less serious than the decreased exports of British manufactures to protected countries, is the increased, and increasing, import of foreign manufactured goods into this country. It has been, and still is, contended that the free import system is a source of national wealth, and that the growth of imports is a development over which the people of Great Britain should rejoice exceedingly.

Examination of available statistics does not lead us to share such opinions, and it is difficult to believe that they can be held by any man in the possession of his senses.

The Board of Trade Returns show that our imports of manufactured goods from 1872 to 1902 have been—

1872	£63,000,000
1882	94,000,000
1892	99,000,000
1902	149,000,000

Again, the statistics of importation for the period 1882–1902, analysed and presented in the form of percentages, give the following results :—

Year.	Food.	Raw Materials.	Manufactures.
1882	43·7	40·2	12·5
1887	42·1	39·3	15·0
1892	44·4	36·5	15·4
1897	42·9	34·8	18·9
1902	42·5	35·0	18·7

From these figures we find that raw materials show a steady and considerable decline, and that manufactured goods show a most ominous increase.

Here we see most clearly the baleful influence of the free import system. The smaller percentage of raw materials and the larger percentage of manufactures imply direct loss to British manufacturers, and a direct loss of wages to British workmen.

Quite an opposite tendency is observable in the case of Germany. Thus, taking percentages in the same way for the period 1880–1900, we have—

Year.	Food.	Raw Materials.	Manufactures.
1880	32·6	39·6	27·8
1885	30·3	41·2	28·5
1890	33·5	42·9	23·6
1895	33·7	43·8	22·5
1900	30·0	48·6	20·8

Food imported here shows a slight decline, while imports of raw materials have greatly increased, and imports of manufactured goods have fallen to a corresponding extent.

If protection be wrong, then it must be equally wrong to encourage national industries, for the experience of Germany proves conclusively that the two things are inalienably connected.

Let us now look a little more closely at the character of British imports. The total imports of iron and steel, including machinery, into the United Kingdom amounted to less than £1,500,000 in 1870, to nearly £4,000,000 in 1880, to £16,250,000 in 1901, and to more than £16,000,000 in 1902; the most prominent item in this wonderful increase being machinery.

It should be noted that while our imports of iron and steel, excluding iron ores, amounted to £10,250,000 in 1901, they had decreased to about £7,300,000 in 1902. On the other hand our imports of machinery, millwork, electrical apparatus, cycles, motor cars, cutlery, and hardware, increased from £6,000,000 in 1901 to more than £8,600,000 in 1902.

We sometimes hear the contention that a large proportion of our imports, classified under the general head of iron and steel, should be regarded as raw materials for use in the manufacture of more highly finished goods. This theory rests upon a very unsubstantial basis, for of the total imports of iron and steel in 1902 only about £3,300,000 out of £16,000,000 can be justly classified as raw material to be employed in this manner. Therefore no more than 20 per cent. of these imports consists of raw material, and the balance of 80 per cent. is made up of finished products.

This condition of things is an absolute condemnation of the free import system in a country which, like our own, is so largely dependent upon the prosperity and expansion of the iron and steel industries.

Turning now to some other branches of trade, we find equally small cause for congratulation.

Of the various industries which are being affected by imports of foreign-made goods, mention must be made of the glass trade, which has suffered more than any from the pernicious influence of the free import system. St. Helens, the principal centre of the glass industry, is losing trade year by year. Factory after factory has been shut down, and within the last two or three months one of the largest plate-glass works in the district has been closed. At one time the bulk of the world's supply of glass came from St. Helens, but to-day the industry is nearly dead.

Years ago the Tyne was almost as well known for glass as for coal, but the trade has practically vanished. No fewer than twenty-five glass works have been closed through foreign competition. Within thirty years the imports of glass have increased threefold, and on the Tyne, as well as at St. Helens, large numbers of British workmen have lost their occupation; and yet we are told that free imports constitute the greatest blessing this country has ever known.

Let us take also the case of chemicals. Widnes, once the chief seat of the industry, has lost its pre-eminent position. Nothing can stand against foreign duties and free markets at home. So trade in Widnes has declined year by year, its population decreased from 30,000 to 28,580 between 1891 and 1901, and the working classes are suffering severe privation. Branch after branch of the brass trade has been ruined by the free importation of German goods, while the more astute foreigner charges a duty of 25 per cent. on British manufactures of the same class.

It would be easy to multiply instances of the ruin caused by the folly of our effete fiscal regulations, but we have said enough to show the urgent necessity existing for reform. Some people tell us there is no need for reform, because, on the whole, the country has prospered since the free-import system was introduced. We do not for a moment deny the fact that there has been much prosperity, but we emphasize the point that many important industries have been ruined, and others are being ruined, by the system wrongly termed "free trade." Further, we contend that the country has not prospered

to anything like the extent evidenced in other countries that are protective, and have been so for many years. If protection would be bad for the United Kingdom, it should be bad for other countries; but we know by the prodigious strides made in Germany and the United States that the protection of national industries has proved to be both wise and judicious. The trade of the United Kingdom has prospered in spite of the free import system, and not because of it.

If any further argument were required to prove the necessity for protective legislation, it would be sufficient to read the alarmed comments of foreign newspapers upon the proposals now made for the reform of British fiscal legislation. These journals all regard with apprehension the movement now in progress for the preservation of British trade and manufactures. And they have good reason to fear, for, as an American newspaper aptly remarks, "Whoever does not perceive that Mr. Chamberlain's proposal is for the benefit of England and Englishmen, is a fool. Woe to any trading people, German or Yankee, which does not recognise the momentous situation and prepare for the results."

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Standard Direct Current Pressures and Standard Frequencies.

ANOTHER stage has been reached in the labours of the Engineering Standards Committee by the issue of the report of the Sub-committee on Generators, Motors and Transformers, to whom was entrusted the important work of fixing the standards of electrical pressures and frequencies.

It was decided that the most advantageous method of approaching the problem would be from the point of view of those most affected, viz., the users of lamps and of motors for power purposes. It was, therefore, agreed that the standard pressures to be suggested should be measured at the consumers' terminals, as settled by the Act of 1899.

After careful consideration, it became evident to the sub-committee that the direct current pressures of 110, 220, 440, and 500 volts would best meet the requirements, because carcases built for these standard pressures could be utilised for pressures 10 per cent. above or below the suggested standards, without any alteration whatever in the castings or mechanical components, by merely altering the windings and excitation.

Before coming to their final decision, the Sub-committee on Generators, Motors and Transformers conferred with the Sub-committee on Electrical Tramways, and a joint meeting took place, with the result that the pressure of 500 volts, which most concerned the latter sub-committee, was agreed to, and in addition to the pressures already agreed to, 600 volts was decided upon as the standard pressure for electrical railways.

The question of the adoption of standard frequencies, although of equal importance with that of standard pressures, was not surrounded with the same difficulties. It was, however, deemed advisable to fix upon the standard frequencies at the earliest possible stage of the work, as no progress could be made in the standardisation of prime movers for driving alternate current machinery until such time as the frequencies had been settled upon. On this question there appeared to be a great preponderance in favour of frequencies of 25 and 50. The only point upon which any serious difference of opinion appeared to exist was the advisability of the adoption of a third frequency of 40 or 42, to enable rotary converters to be used to the fullest advantage. All the arguments in favour of this third frequency were fully discussed, but after carefully weighing the *pros* and *cons* the sub-committee decided not to recommend the adoption of more than two frequencies, namely, 25 and 50.

The recommendations of the sub-committee were then submitted to the Electrical Plant Committee, the Publication Committee, the Main Committee, and the Board of Trade for their approval.

This having been obtained, it was deemed advisable, in the interests of the

electrical industry of the country, that the findings on the questions of direct current pressures and frequencies should be published at an early date, without waiting for the completion of the entire Report to be issued at a later date.

The following are the resolutions on standard direct-current pressures and standard frequencies:—

(1.) That the standard direct-current pressures, measured at the consumers' terminals, be:
110, 220, 440, 500 volts.

(2.) That the standard direct-current pressures, measured at the terminals of the motors, be:
For tramways, 500 volts.
For railways, 600 volts.

(3.) That 25 periods per second be the standard frequency for:
(*a*) Systems involving conversion to direct current by means of rotary converters.
(*b*) Large power schemes over long distances.
(*c*) Three-phase railway work, where motor gearing and the inductive drop on the track rail have to be considered.

(4.) That 50 periods per second be the standard frequency for:
(*a*) Mixed power and lighting on town supply mains.
(*b*) Ordinary factory power plant.
(*c*) All medium-size power plant where rotary converters are not employed.

It is to be hoped that now these direct-current pressures have been fixed as standards by the Committee, they will in future be universally adopted by the engineers advising corporations and others distributing electrical energy. In course of time the benefits to the electrical industry at large, which will certainly follow the adoption of these standard pressures, must become more and more apparent.

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The Edison Storage Battery.

ACCORDING to the *Electro-Chemist and Metallurgist*, recent information from the States is to the effect that the much-discussed Edison accumulator is now being placed on the market at the moderate selling price of 15 dols. each. A big factory is apparently in course of erection to deal effectually with the manufacture of this battery, and when these works are in full swing it is anticipated that the selling price will be further reduced.

Some further figures are now available as to working of the accumulator, the *Electrical World and Engineer* of New York having published an abstract from a report of valuable tests carried out by Mr. W. Hibbert, F.I.C.. on a cell weighing 17·8 lbs. This cell is of rectangular shape, is 13 inches high, and 5·1 × 3·5 inches across. It contains 14 positive and 14 negative plates. Both positive and negative plates are made of nickel-plated sheet-steel punched with rectangular holes. In these holes the pockets containing active material are placed. The pockets in the negative plate contain finely divided iron, those in the positive peroxide of nickel. The electrolyte is a 20 per cent. solution of potash. Since the liquid simply acts as an electrolytic conductor and not as active material, a small quantity only is required: on this account, as also owing to the rigidity of the steel plates, the electrodes can be placed very close together. The cell is sealed air-tight in its steel case, a valve being supplied for the exit of the gases. The e.m.f. of the cell is 1·33 volts, the internal resistance 0·0013 ohms. The output at 60 ampères is 210 watt-hours, or at the rate of 11·8 watt-hours per lb. of cell. Curves are given showing the p.d. during discharge at varying rates from 30 to 200 ampères. At 120 ampères the output was 91 per cent. of the maximum, whilst even at 200 ampères, the quantity (ampère-hours) is 82 per cent. of the maximum. Other curves represent a case in which the discharge was started at 60 ampères; after five minutes this was increased to 230 ampères, then again reduced to 60, and so on. The cell yielded the high current, and recovered almost instantaneously. A high charging-rate can also be employed without harm. After three months' work the capacity of the cell had remained the same, neither increasing nor diminishing.

Experiments with Rapid-Cutting Steel Tools.

DURING the past month a special meeting of the Manchester Association of Engineers was held for the purpose of receiving a report prepared by Dr. J. T. Nicholson on a series of experiments with rapid-cutting steel tools. The investigations were carried out at the Manchester Municipal School of Technology, under the auspices of a joint committee of members of the Manchester Association of Engineers and of members of the School of Technology sub-committee, together with Dr. Nicholson, who is the professor of mechanical engineering at that school.

All the tool steel making firms whose names were familiar to members of the committee at that time as having specialised a steel for rapid cutting were written to and invited to participate in the trials, under conditions then issued, by sending tools and having representatives present during the experiments with their own tools. The names of the tool steel makers who accepted this invitation and sent tools for the experiments will be found in the tables giving the results. Applications received later from other steel making firms wishing to participate had to be refused to avoid prolonging the trials unduly, it being felt that a sufficient number had entered to render the experiments of value for the guidance of tool steel users as to the possibilities of the new steels.

It was decided to confine the experiments to lathe tools, and to record the weight of material removed, area of surface machined, cutting speed, depth of cut, traverse per revolution, duration of trial, condition of tool at end of trial, and power absorbed during the trial. The angles of the tools, how hardened and ground, the height of the cutting edge in relation to centre of lathe, were also to be noted.

After careful consideration it was decided to leave the shape of the tools to the makers rather than specify the angles to which the tools were to be ground, the reason for this decision being that the intention of the experiments was to bring out the best results obtainable rather than to ascertain which was the best brand under equal competitive conditions. This could be ascertained by tool steel users for themselves.

It was decided that the following should be the percentage of carbon in the steels to be operated upon :—

Soft Steel...	0·2 %
Medium Steel	0·3 %
Hard Steel	0·5 %

A preliminary trial was made on that date with a 10-in. lathe obtained from Messrs. Hetherington & Sons ; but it was found that the capacity of the lathe was not great enough for the size of bars, both as to diameter and length, which it would be necessary to operate upon in order to have sufficient surface for the speeds and lengths of trial intended.

The committee then accepted the offer of Messrs. Sir W. G. Armstrong, Whitworth & Co., Ltd., to place a lathe of greater capacity at their disposal for the purpose of the experiments ; as also the further offer to supply, free of charge, the three bars of steel and the three bars of cast-iron required for the tests.

The careful consideration of the committee was given to the question of the duration of the various trials, and the cut and traverse to be taken upon each. The following four series of trials were made upon each of the six materials operated upon :—

Object of Trial.	Cut.	Traverse
1. To remove maximum weight per minute ...	$\frac{3}{8}$	$\frac{1}{8}$
2. To machine maximum area of surface	$\frac{3}{16}$	$\frac{1}{8}$
3. To obtain maximum cutting speed	$\frac{3}{16}$	$\frac{1}{16}$
4. To obtain maximum cutting speed	$\frac{1}{16}$	$\frac{1}{16}$

Duration of trials upon		Soft Steel ..	20 minutes.
,,	,,	Medium Steel	30 ,,
,,	,,	Hard ,	30 ,,
,,	,,	Soft Cast-iron	30 ,,
,,	,,	Medium ,,	30 ,,
,,	,,	Hard ,,	60 ,,
		for $\frac{3}{16}$ by $\frac{1}{8}$ cuts.	
,,	,,	Hard Cast-iron	30 ,,
		for all others.	

As an amendment to the first instructions issued to the tool makers it was agreed to allow them to submit 24 tools, instead of 12 ; one for each of the four trials on the six specimens to be operated upon, or, in case

they should prefer to use one tool for two tests, as originally intended, it was agreed that such tool might be re-forged or re-ground at the School in the presence of the Committee. Soon after the commencement of the trials competitors were allowed to increase their cutting speeds during a trial by an amount not exceeding 12½ per cent. of the speed at starting.

A series of "*endurance*" tests was also carried out. These trials were of two hours' duration, and were made with one tool of each maker upon both soft steel and medium cast-iron (of which materials sufficient remained for these further experiments). The tools were chosen from those already used, and were re-forged at the School to the makers' instructions, and afterwards ground to a shape common to all.

Procedure in Making the Tests.

The mode of procedure in carrying out the trials was as follows :—

In all cases the skin was first removed, and the bar was machined over at the same traverse as that to be used in the test, so that sufficient area of surface was available for the trial at the speed of cutting and duration proposed.

A sketch was then made of the bar, and its diameters accurately measured in two or more places in the part to be operated on. The distance from the end of the bar at which the cut was to commence was measured.

The tool, having been measured, was placed in position to the instructions of the steel maker's representative, its position relatively to the centre of the work and its overhang from the slide rest being noted.

The lathe having meanwhile been started, observations of the surface speed of the bar were taken, and the motor speed adjusted until the desired cutting speed of the job was arrived at.

The self-acting traverse was then put in gear, and the tool set up until the point of the tool just scraped the bottom of the groove left by the last turning. This tool slide screw was fitted with a disc having its edges marked with a zero mark, and with the four depths of cut usually employed—viz., $\frac{1}{16}$ in., $\frac{1}{8}$ in., $\frac{3}{16}$ in., $\frac{1}{4}$ in.; and any one of those marks could be set opposite to an index mark on the tool-rest. When the tool was set up to the work as described, care was taken that the disc was at zero.

The self-acting gear was then thrown out, the slide screw turned back a little, and the saddle moved to the right by hand sufficiently to clear.

The tool slide screw was then used to set the tool forward until the disc showed the required cut opposite the index mark. The tool was then ready for starting the test.

At the time of entering upon the cut the time was exactly noted, and another observer noted the reading of a revolution counter worked from a crank on the lathe spindle.

This counter, as also the voltmeter and ammeter connected with the motor brushes, were read every two minutes throughout the trial ; frequent observations of the motor speed were also made with a Horn's Tachograph, which read accurately.

If the tool kept a reasonably good point, and appeared to be cutting all right, it was not withdrawn until the expiration of an agreed-upon time, such as 20, 30, or 60 minutes, even if it had ceased to take the full cut to which it was set.

After withdrawal of the tool the lathe was run for a little while at the average speed of the trial, to enable the electrical horse-power exerted by the motor, in running it light, to be observed. This was always necessary, as the bars were differently supported with wood chocks in different trials, and the friction horse-power running light varied considerably.

All cuttings were collected and weighed.

Description of Lathe used for these Trials.

The lathe was a 15-in. centre screw-cutting lathe, taking in a length of 9 ft. 6 ins. between centres. For these experiments it was fitted with 18-in. centre headstocks ; the fast headstock having both double and treble back gears, the gear-ratio being 14·9 to 1 and 42·5 to 1. This headstock was specially fitted with a three-step cone suitable for a 6-in. belt. The bed was replaned, and a new compound slide-rest was fitted.

The lathe was driven by a direct-current shunt-wound Schuckert motor of 120 e.h.p., supplied with current from the three-wire power leads of the school at a voltage of 220. A large air-cooled rheostat of 38 steps, with a maximum resistance of 3·2 ohms, was connected in the main circuit between line and brushes, and with this apparatus the speed of the motor could be varied between 150 and 300 revolutions per minute at no load on the lathe, and from 60 to 300 revolutions per minute with heavy cuts by simply moving the rheostat handle, as shown in Fig. 1.

The lathe was driven through two intermediate countershafts. The motor pulley 30-in. diameter drove on to a 36-in. diameter pulley by a 10-in. belt. From the first countershaft another 10-in. belt drove from a 36-in. pulley thereon to a 30-in. pulley on the second

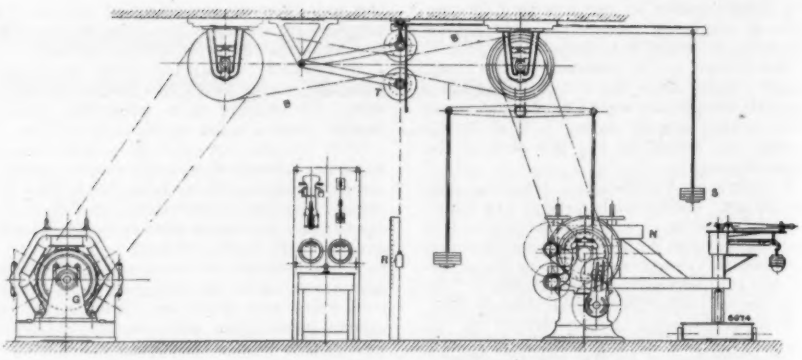


FIG. 1.—METHOD OF DRIVING AND OF MEASURING FORCE TRANSMITTED.

countershaft. On the latter three pulleys were set opposite the three cone pulleys on the lathe.

Diameter of pulleys :—

Countershaft	32·7 ins.	27·85 ins. and 23·68 ins.
Lathe cone	15·67 ins.	19·58 ins. and 23·58 ins

Thus the speed ratio of lathe spindle to motor shaft was as follows :—

Particulars of Drive.		Spindle to Motor.	Surface speed of Bar, 5 ft. circumference, with motor running at		
Gear.	Cone Pulley	Speed ratio.	300 revs. per min.	200 revs. per min.	100 revs. per min.
Single	Small	2·075	3130	2086	1043
,,	Middle	1·413	2120	1414	707
,,	Large	1·0	1500	1000	500
Double	Small	·14	209	138	69
,,	Middle	·0954	143	96	48
,,	Large	·0674	101	68	34
Treble	Small	·0490	7·35	49	24·5
,,	Middle	·0334	50·2	33·4	16·7
,,	Large	·0235	35·3	23·6	11·8

Any required cutting speed between 12 ft. and 200 ft. per minute could thus be obtained with the back gears in use, upon a bar of 5-ft. circumference with great convenience.

Description of the Apparatus used and the Methods adopted for Measuring the Force required in Cutting.

At every trial observations of the current supplied and of the brush-volts of the motor were made every two minutes during the cut; when the tool had been withdrawn, and the motor speed thereafter re-adjusted to its average during the test, two readings were taken of the same quantities with the lathe running light. The difference between the electrical horse-power of the motor when driving the cutting tool and when only driving the lathe and intermediate gearing gives the net horse-power required for cutting, and if this be multiplied by 33,000 and divided by the cutting speed, we obtain the force exerted in cutting in pounds.

The correctness of the figure so deduced depends upon the accuracy of the assumption which underlies this method —that the waste horse-power of the drive remains the same when the lathe is cutting as when it is running light (with the forging in place). This waste horse-power consists of —firstly, lost electrical energy in the motor, due to ohmic resistances in armature and field, eddy currents in armature-cores and pole-pieces, and hysteresis in the armature-cores; secondly, mechanical frictions in the motor, the countershafts, and the lathe, work lost by the bending and unbending, and the slip and creep of the belts.

A considerable number of experiments were made to verify the truth of this assumption. A Prony brake was mounted upon the forging in the way shown in Fig. 1, and could be clamped so as to offer as great a resistance to turning as the tool-point on its heaviest cut, the whole being cooled by water. The torque exerted by the brake

was observed by noting readings on the scale-beam of a weighing machine, on whose platform the thrust of the brake-lever was taken, at a known distance from the lathe-centre.

Advantage was also taken of the horizontal belt between the two countershafts to install a belt dynamometer of the kind first used by Von Hefner Alteneck. Its nature is readily understood from Fig. 2. The horse-power transmitted is known from the value of the weight which must be placed in the scale-pan, S, in order to maintain the dynamometer frame in its zero position (as indicated by pointer and scale, R), and from the observed speed of the belt, BB. Thus the gross electrical horse-power of the motor, G, the horse-power transmitted through the dynamometer, T, and the horse-power delivered upon the Prony brake, N, were separately measured.

Experiments were made with the lathe running under all the six possible modes of driving it through its two back gears—from no load to that at which the belt slipped, the motor speed being kept constant throughout. Runs were also made at constant load under three different motor speeds with the double back gear only.

The results of these trials were plotted with the transmitted (or dynamometer) horse-power, T; the net horse-power (or that absorbed by the Prony brake, N); and the lost horse-power between motor and brake, L, as ordinates, upon a base of gross electrical horse-power, G, absorbed by the motor; and from the diagrams so obtained the following formulæ connecting the lost horse-power, L, the nett or brake horse-power at the lathe, N, and the gross electrical horse-power, G, were deduced :—

$$L = 10 + \tfrac{1}{8}N \quad \ldots \quad \ldots \quad \ldots \quad (1)$$
$$N = 0{\cdot}9G - 9 \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

This applies to a constant motor speed of 250 revolutions per minute, and for all gears and cone steps.

By plotting all the light run horse-powers, L_0, of the main trials as ordinates on a base of motor speeds, the expression :—

$$L_0 = 0{\cdot}0375R + 0{\cdot}6 \quad \ldots \quad \ldots \quad (3)$$

was obtained, giving the connection between total lost horse-power and motor speed (R in revolutions per minute), with the lathe running light.

Thus a general expression for the lost power, taking account both of motor speed and load, is

$$L = 0{\cdot}0375R + 0{\cdot}6 + \tfrac{1}{8}N \ldots \quad \ldots \quad (4)$$
$$\text{or } L = 0{\cdot}0375R + 0{\cdot}1G - 0{\cdot}4 \quad \ldots \quad (5)$$

Expression (1) shows that the lost horse-power increases somewhat with the load, and does not remain constant as required by the above-mentioned assumption. It was also found that the friction or lost horse-power was much affected by the condition of the lathe at the commencement of the experiment. If newly started up with lubricants cold and viscous, the lost power would be from $\frac{1}{2}$ to $1\frac{1}{2}$ h.p. more than when the lathe had become thoroughly warmed up, as after a lengthened run. On this ground a careful re-examination of all the log sheets and results was made; and corrections were introduced in the horse-power readings, which are recorded in the Tables XIII. to XVIII., under col. 6, to allow for the condition of the lathe as to temperature.

These corrections in the net horse-power from which the cutting forces are deduced are especially important at the light cuts; and although it is believed that the cutting forces and stresses, as deduced, are not far from the truth, those given for the lighter cuts ought not to be regarded with the same degree of confidence which the figures for the heavy cuts may claim.

Results of Experiments.

The results obtained with the eight different brands of steel experimented upon, as regards area machined and weight removed at the various speeds and cuts, are recorded in Tables I., II., III., IV., V., and VI.; one for each of the six materials operated upon.

In each of these tables there are four groups of tests, one for each of the four different cuts, viz :—$\frac{1}{16}$ in. cut by $\frac{1}{16}$ in. traverse; $\frac{3}{16}$ in. cut by $\frac{1}{16}$ in. traverse; $\frac{3}{16}$ in. cut by $\frac{1}{8}$ in. traverse; and $\frac{3}{8}$ in. cut by $\frac{1}{8}$ in. traverse.

The 1st col. gives the names of the tool-steel makers in alphabetical order; the 2nd the name of brand of steel; the 3rd col. gives the number of the trial. Cols. 4, 5, and 6 give the speeds, cuts, and traverses at which the trials were intended to be carried out; whilst 7, 8, and 9 give the actual speeds, cuts, and traverses at which the tests took place, as found by measurement and observation. By the cutting speed is meant the speed in feet per minute of the cylindrical surface, obtained by taking the mean diameter of the work before and after machining. The depth of cut was, of course, half the difference between these two diameters, which were measured by micrometer calipers in from one to three places. The traverse was the distance along the job from the start to the finish of the cut, divided by the number of revolutions of the lathe-spindle made during the cut. Col. 10 gives the area of section of cut,

being the product of cut and traverse. Col. 11 gives the duration of the trial in minutes. Cols. 12 and 13 give the area machined during the trial and the area machined per minute in square feet; whilst cols. 14 and 15 give the total weight of cuttings removed during the run and the weight removed per minute. These results were obtained by the collection and weighing of the cuttings. Col. 16 gives the reason for the withdrawal of the tool. Col 17 gives the number representing the relative condition of the cutting edge of the tool after the experiment, a lower number indicating superiority in this respect.

Table VIA. gives the results of the trials made with ordinary water-hardened and ordinary Mushet steel tools upon soft steel, and upon soft and medium cast-iron.

These trials show that 20 ft. per min. with a cut of $\frac{1}{16}$ in. by $\frac{1}{16}$ in. is the superior limit of speed for ordinary water-hardened steel operating upon Whitworth fluid-compressed soft steel; whilst an ordinary Mushet tool can run at over 30 ft. per min., with a $\frac{3}{16}$ in. by $\frac{1}{16}$ in. cut upon the same material.

Experiment No. 26, entered in this table, was a heavy cut $\frac{3}{8}$ in. deep by $\frac{3}{8}$ in. traverse, to test the driving power of the belts. The cutting stress deduced from this trial is 128 tons per square inch, which figure further verifies the linear law of variation of cutting force with area of cut for steel.

With regard to the trials on medium cast-iron, it appears that 25 ft. per min. is too high a speed with $\frac{1}{16}$ in. by $\frac{1}{16}$ in. cuts; 17 ft. is too high with $\frac{3}{16}$ in. by $\frac{1}{16}$ in. cuts; and 15 ft. is too high with $\frac{3}{16}$ in. by $\frac{1}{8}$ in. cuts for ordinary water-hardened tool steels. An ordinary Mushet ran for over 20 min. at 23·6 ft. per min. on a $\frac{1}{16}$ in. by $\frac{1}{16}$ in. cut; whilst it failed at 19 ft. per min. on a $\frac{3}{16}$ in. by $\frac{1}{16}$ in. cut, and at 15 ft. per min. on a $\frac{3}{16}$ in. by $\frac{1}{8}$ in. cut on this material.

In the case of soft cast-iron, 22 ft. per min. was too high a speed for water-hardened steel taking a $\frac{3}{16}$-in. cut by $\frac{1}{8}$-in. traverse; whilst an ordinary Mushet lasted over half-an-hour at 31·6 ft. per min. with the same cut upon the same material.

The next tables, numbered VII. to XII., give the particulars of the tool angles and position of tools when cutting. Col. 1 gives the steel maker's name, and col. 2 the number of the experiment. Col. 3 records the *front cutting angle* of the tool; that is, the angle between a line in the top surface of the tool through its point, and a line tangent to the work at the tool point, both these lines lying in a plane perpendicular to the axis of the work or lathe. Col. 4 gives the top rake (ϵ^0).

The *front clearance angle* given in col. 5 is the angle between the tangent just mentioned and the front of the tool (C^0 in tool diagrams).

The *side cutting angle* given in col. 6 is the angle between a line in the top surface of the tool, taken in a vertical plane parallel to the axis of the lathe, through that point of the cutting edge where it is intersected by the uncut surface of the work, and a vertical line through the same point.

The *side clearance angle* is the angle between the last-mentioned vertical line and the line of intersection of the vertical plane containing it with the (cutting) side of the tool (k^0 in tool diagrams).

In cols. 7 and 8 are tabulated the values of what may be called the *true cutting angles*. They are taken in the vertical plane containing the direction of motion of the shaving whilst in contact with the top of the tool, and are measured both before and after the tool has made the cut. The direction of motion of the shaving over the tool point can be very approximately inferred from the appearance of the tool, as in many cases the shaving rubs away a portion of the top surface of the tool, leaving the cutting edge intact, and indicating the direction of flow of shaving. The true cutting angle is thus rendered more acute than when the tool began the cut. In such cases it was observed that shaving was curled to a smaller radius as the test progressed.

When the direction of motion of the shaving differed considerably from that of the tool axis, this so-called true cutting angle of the tool differs materially from the front cutting angle. In most cases, however, there is but little difference.

Strictly, these angles ought to be taken relatively to a line tangent to the work at the tool point, as for the front-cutting angle, but for simplicity they were measured relatively to a vertical angle; and this amounts to neglecting the angle β, which the height of tool point above centre subtends at the axis of the work.

Col. 9 gives the height of the tool point above the centre line of the lathe, and col. 10 the angle this height subtends at the centre of the work θ, Fig. 2.

Col. 11 records *the cutting arc*, or length of the tool point which was operating upon the work. This practically is the same width as the shaving.

In Tables XIII. to XVIII. are recorded the results obtained with regard to gross, tare, and net horse-power required in the trials, and to the force acting upon the tool point when cutting; each table having

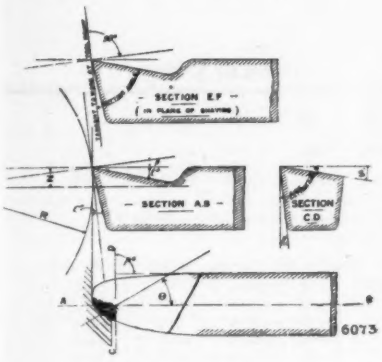


FIG. 2.

reference to one of the six materials operated upon.

The cols. 1 and 2 give the tool-maker's name and the number of the experiment. Col. 3 gives the gross electrical horse-power absorbed by the motor when the tool was cutting. Col. 4 gives the frictional horse-power, or that observed when the lathe was running light at the same speed as when cutting. Col. 5 gives the difference between 3 and 4, and is the net horse-power required for cutting, as determined from these electrical readings. Col. 6 gives the net horse-power as in col. 5, but corrected by allowances being made for extra friction due to the lathe having been run cold in some experiments, and not in others (*v.* Part V.). Col. 7 gives the average speed of cutting; and from cols. 7 and 5 col. 8 is deduced, giving the calculated cutting force upon the point of the tool. Col. 9 gives the product of the cut and traverse, or the area of the cut in square inches. Col. 10 gives the motor speed, and col. 11 the nature of the gear in use during the run. Below cols. 8 and 9 are given the average cutting stress in tons per square inch for each group of tests. They are obtained by dividing the average cutting force in tons by the average area of section of cut in square inches.

Relation between allowable Cutting Speed and Area of Cut with Different Materials.

Figs. 3 and 4 depict the variation of the speeds of cutting which obtained with the six kinds of material operated upon, as depending upon the area of the cut. Fig. 3 is for the soft, medium, and hard steel; and Fig. 4 for the same varieties of cast-iron. In each case the full-line curves give the maximum speed at which any tool ran the full time at the given cut; whilst the dotted-lined curves indicate the *average speeds* at which the given area of cut was taken by all the tools tested, whether any of them failed to complete the trial or not

The following simple approximate expressions indicate the relations depicted in the curves, between speed of cutting and area of cut:—

Let v = cutting speed in feet per minute, and a = area of cut in square inches (product of cut and traverse). Then—

For soft steel $$v = \frac{1{\cdot}943}{a + 0{\cdot}011} + 14$$

For medium steel $$v = \frac{1{\cdot}823}{a + 0{\cdot}016} + 5$$

For hard steel $$v = \frac{1{\cdot}77}{a + 0{\cdot}027} - 5$$

For cast iron the results are not of so

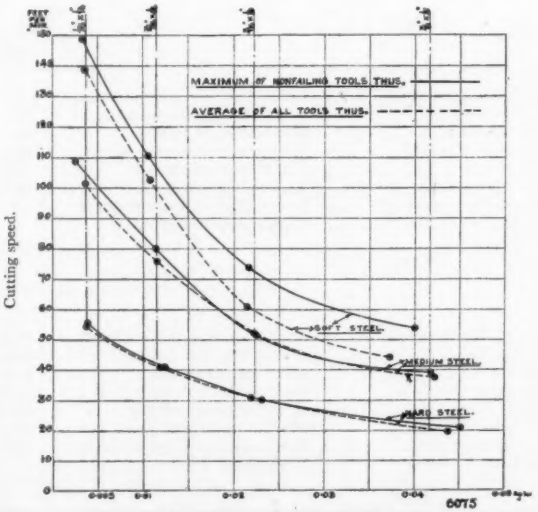


FIG. 3.—VARIATION OF CUTTING SPEED, WITH AREA OF CUT—STEEL.

TABLE I.—

1 TOOL STEEL MAKERS (Arranged alphabetically).	2 Name of Brand of Steel.	3 No. of Trial.	4 Intended Speed.	5&6 Intended Cut and Traverse.	7 Actual Speed.
				Object of Trial :—	
			Ft. per min	Inches.	Ft. per min
Armstrong, Whitworth & Co. ...	A. W. high-speed Tool Steel	1	200·0		193·0
Samuel Buckley...	Bohler ❋ Rapid self-hard ...	9	100·0		106·0
John Brown & Co.	Atlas self-hard Steel	7	150·0	$\frac{1}{16}$	163·5
C. Cammell & Co.	Special self-hardening Steel ..	13	150·0	by	149·2
T. Firth & Sons	N.F.K. Speedicut	5	130·0	$\frac{1}{16}$	128·0
Samuel Osborn & Co.	Mushet high-speed Steel ...	3	110·0		114·0
Seebohm & Dieckstahl	New capital high-speed Steel	15	130·0		124·5
Vickers Sons & Maxim ...	High-speed Steel	11	130·0		132·5
Means ...					138·8
				Object of Trial :—	
Armstrong, Whitworth & Co. ...	A. W. high-speed Tool Steel	2	110·0		111·0
Samuel Buckley...	Bohler ❋ Rapid self-hard ...	10	100·0	$\frac{3}{16}$	108·0
John Brown & Co.	Atlas self-hard Steel	8	100·0	by	98·6
C. Cammell & Co.	Special self-hardening Steel ..	14	120·0	$\frac{1}{16}$	121·0
T. Frith & Sons	N.F.K. Speedicut	6	80·0		93·5
Samuel Osborn & Co.	Mushet high-speed Steel ...	4	75·85		83·0
Seebohm & Dieckstahl	New capital high-speed Steel	16	100·0		100·9
Vickers Sons & Maxim ...	High-speed Steel	12	110·0		106·4
Means ...					102·8
				Object of Trial :—	
Armstrong, Whitworth & Co. ...	A. W. high-speed Tool Steel	38	75.0		74·0
Samuel Buckley...	Bohler ❋ Rapid self-hard ...	31	40·0	$\frac{3}{16}$	38·73
John Brown & Co.	Atlas self-hard Steel	40	60·0	by	63·5
C. Cammell & Co.	Special self-hardening Steel ..	29	60·0	$\frac{1}{8}$	61·06
T. Firth & Sons	N.F.K. Speedicut	35	65·70		66·6
Samuel Osborn & Co.	Mushet high-speed Steel ...	27	75·0		72·88
Seebohm & Dieckstahl	New capital high-speed Steel	33	60·0		52·2
Vickers Sons & Maxim ...	High-speed Steel				
Means ...					61·28
				Object of Trial :—	
Armstrong, Whitworth & Co. ...	A. W. high-speed Tool Steel	39	60·0		54·5
Samuel Buckley...	Bohler ❋ Rapid self-hard ...	32	25·0	$\frac{3}{8}$	28·96
John Brown & Co.	Atlas self-hard Steel	41	50·0	by	50·75
C. Cammell & Co.	Special self-hardening Steel ..	30	35·0	$\frac{1}{8}$	37·35
T. Firth & Sons	N.F.K. Speedicut	36	50·60		52·5
Samuel Osborn & Co.	Mushet high-speed Steel ...	28	45·0		49·3
Seebohm & Dieckstahl	New capital high-speed Steel	34	40·0		38·30
Vickers Sons & Maxim ...	High-speed Steel				
Means ...					44·52

SOFT STEEL. 1

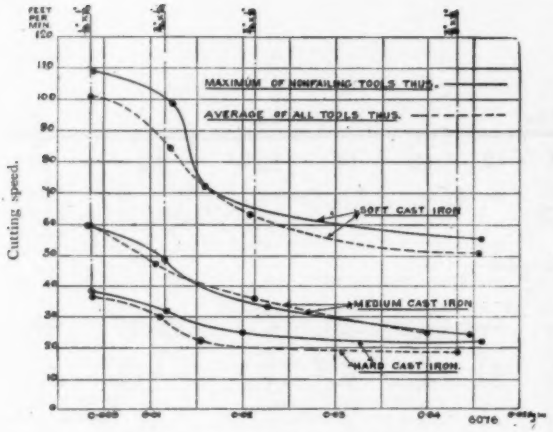
8	9	10	11	12	13	14	15	16	17
Actual		Area of Section of Cut.	Duration of Trial.	Area Machined.		Weight removed.		Cause of Withdrawal.	Relative condition of tool after trial.
Cut.	Traverse.			Total.	Per min.	Total.	Per min.		
To obtain Maximum Cutting Speed.									
Inches.	Inches.	Sq. ins.	Minutes	Sq. feet.	Sq. feet.	Lbs.	Lbs.		
0·054	0·0626	0·00338	7·5	7·56	1·00	15·75	2·1	Tool failed	7
0·0585	0·0625	0·00365	20·0	11·05	0·552	27·75	1·387	Time up	1
0·0605	0·063	0·00381	6·0	5·14	0·856	11·75	1·96	Tool failed	7
0·052	0·0624	0·00325	20·0	15·5	0·755	34·5	1·72	Time up	2
0·0585	0·0627	0·00367	20·0	13·4	0·67	27·75	1·387	do.	5
0·055	0·0625	0·00344	20·0	11·9	0·595	26·5	1·325	do.	2
0·0595	0·0625	0·00372	17·83	11·55	0·648	28·0	1·57	Tool failed	6
0·058	0·0625	0·00362	20.0	14·25	0·712	29·0	1·45	Time up	2
		0·00357							
To obtain Maximum Cutting Speed.									
0·170	0·0624	0·0106	20·0	11·5	0·575	82·75	4·137	Time up	1
0·170	0·0619	0·01058	7·25	4·14	0·56	29·0	3·92	Tool failed	4
0·1805	0·0625	0·01280	5·53	2·8	0·520	19·0	3·56	do.	6
0·177	0·0620	0·01096	6·16	3·84	0·623	27·25	4·43	do.	5
0·164	0·0621	0·01018	20·0	9·95	0·497	64·5	3·225	Time up	1
0·1670	0·0622	0·01038	20·0	8·56	0·428	58·0	2·9	do.	1
0·1855	0.0571	0·01060	1·585	0·769	0·4859	6·25	3·94	Tool failed	8
0·172	0·0607	0·01040	6·66	3·58	0·537	25·5	3·89	do.	6
		0·01081							
To Machine Maximum Area of Surface per minute.									
0·172	0·125	0·0215	20.0	15·1	0·756	104·75	5·28	Time up	4
0·1810	0·125	0·0226	20·0	8·036	0·4018	60·5	3·025	do.	1
0·1590	0·125	0·0199	20·0	13·22	0·661	88·25	4·41	do.	2
0·159	0·125	0·0199	20·0	12 7	0·635	83·25	4·162	do.	2
0·1725	0·125	0·02155	20·0	13·75	0·687	93·0	4·65	do.	4
0·1627	0·125	0·02035	20·0	14·75	0·787	95·5	4·77	do.	4
0·1485	0·124	0·0185	10·58	5·66	0·535	35·25	3·34	Tool failed	7
		0·02061							
To Remove Maximum Weight per minute.									
0·321	0·125	0·0401	20·0	11·7	0·585	147·0	7·35	Time up	2
0·3705	0·125	0·0463	20·0	6·01	0·300	90·75	4·53	do.	1
0·3475	0·122	0·0434	20·0	10·22	0·511	150·0	7·5	do.	2
0·370	0·124	0·04625	20·0	7·71	0·385	112·0	5·6	do.	2
0·294	0·124	0·0368	20·0	11·16	0·558	134·0	6·7	do.	2
0·3235	0·125	0·0404	20·0	10·25	0·5125	133·0	6·65	do.	2
0·3385	0·124	0·0423	20·0	7·91	0·395	110·5	5·52	do.	7
		0·04222							

TABLE II.—

1 TOOL STEEL MAKER (Arranged alphabetically).	2 Name of Brand of Steel.	3 No. of Trial.	4 Intended Speed.	5&6 Intended Cut and Traverse.	7 Actual Speed.
				Object of Trial : —	
			Ft. per min	Inches.	Ft. per min
Armstrong, Whitworth & Co. ...	A. W. high-speed Tool Steel	79	110·0		109·0
Samuel Buckley...	Bohler ❋ Rapid self-hard ...	91	100·0		105·0
John Brown & Co.	Atlas self-hard Steel	83	90·0	$\frac{1}{16}$	102·0
C. Cammell & Co.	Special self-hardening Steel ..	89	100·0	by	104·5
T. Firth & Sons	N.F.K. Speedicut	81	100·0	$\frac{1}{16}$	105·2
Samuel Osborn & Co.	Mushet high-speed Steel ...	87	80·0		93·0
Seebohm & Dieckstahl	New capital high-speed Steel	85	80·0		93·5
Average ...					101·7
				Object of Trial :—	
Armstrong, Whitworth & Co. ...	A. W. high-speed Tool Steel	80	70·0		67·5
Samuel Buckley...	Bohler ❋ Rapid self-hard ...	92	82·0		89·5
John Brown & Co.	Atlas self-hard Steel	84	70·0	$\frac{2}{16}$	74·7
C. Cammell & Co.	Special self-hardening Steel...	90	80·0	by	80·0
T. Firth & Sons	N.F.K. Speedicut	82	85·0	$\frac{1}{16}$	81·6
Samuel Osborn & Co.	Mushet high-speed Steel ...	88	68·0		70·5
Seebohm & Dieckstahl	New capital high-speed Steel	86	65·0		66·5
Average ...					75·8
				Object of Trial :—	
Armstrong, Whitworth & Co. ...	A. W. high-speed Tool Steel	95	50·0		48·5
Samuel Buckley...	Bohler ❋ Rapid self-hard ...	94	55·0		54·1
John Brown & Co.	Atlas self-hard Steel	99	50·0	$\frac{2}{16}$	49·4
C. Cammell & Co.	Special self-hardening Steel...	102	70·0	by	61·2
T. Firth & Sons	N.F.K. Speedicut	97	50·0	$\frac{1}{8}$	51·5
Samuel Osborn & Co.	Mushet high-speed Steel ...	103	48·0		49·9
Seebohm & Dieckstahl	New capital high-speed Steel	105	50·0		51·4
Average ...					52·3
				Object of Trial :—	
Armstrong, Whitworth & Co. ...	A. W. high-speed Tool Steel	96	40·0		39·0
Samuel Buckley...	Bohler ❋ Rapid self-hard ...	93	35·40		36·0
John Brown & Co.	Atlas self-hard Steel	100	40·0	$\frac{3}{8}$	37·9
C. Cammell & Co.	Special self-hardening Steel...	101	50·0	by	38·5
T. Firth & Sons	N.F.K. Speedicut	98	38·0	$\frac{1}{8}$	36·6
Samuel Osborn & Co.	Mushet high-speed Steel ...	104	38·0		37·5
Seebohm & Dieckstahl	New capital high-speed Steel	106	40·0		38·6
Average ...					37·7

MEDIUM STEEL. 2

8	9	10	11	12	13	14	15	16	17
Actual		Area of Section of Cut.	Duration of Trial.	Area Machined.		Weight removed.		Cause of Withdrawal.	Relative condition of tool after trial.
Cut.	Traverse.			Total.	Per min.	Total.	Per min.		
To obtain Maximum Cutting Speed.									
Inches.	Inches.	Sq. ins.	Minutes.	Sq. feet.	Sq. feet.	Lbs.	Lbs.		
0·036	0·0625	0·00225	30·0	17·05	0·572	30·25	1·008	Time up	2
0·0615	0·0625	0·00384	30·0	16·45	0·548	42·5	1·42	do.	1
0·0635	0·0625	0·00397	30·0	15·9	0·535	41·25	1·37	do.	6
0·060	0·0625	0·00375	30·0	16·3	0·543	39·25	1·308	do.	2
0·0625	0·0625	0·0039	30·0	16·43	0·547	45·0	1·50	do.	2
0·0615	0·0625	0·00384	30·0	14·28	0·476	36·0	1·20	do.	2
0·0605	0·0625	0·00378	30·0	14·60	0·486	37·5	1·25	do.	6
		0·00362							
To obtain Maximum Cutting Speed.									
0·191	0·0625	0·0119	30·0	10·55	0·3516	77·25	2·57	Time up	1
0·195	0·0625	0·0122	10·0	4·18	0·418	34·0	3·4	Tool failed	6
0·185	0·0625	0·01148	30·0	12·0	0·4	89·25	2·97	Time up	5
0·182	0·0625	0·0114	30·0	12·5	0·417	95·0	3·17	do.	2
0·186	0·0625	0·01162	26·75	10·85	0·406	85·0	3·18	Tool failed	6
0·1785	0·0625	0·01120	30·0	10·95	0·365	80·25	2·675	Time up	2
0·184	0·0625	0·0115	30·0	10·45	0·348	78·25	2·608	do.	4
		0·01161							
To Machine Maximum Area of Surface per minute.									
0·171	0·125	0·0214	30·0	15·1	0·503	104·0	3·47	Time up	1
0·180	0·125	0·0225	21·25	11·9	0·56	89·75	4·22	Tool failed	6
0·172	0·125	0·0215	13·78	7·1	0·515	50·25	3·66	do.	4
0·187	0·125	0·0229	9·0	5·72	0·636	42·25	4·7	do.	5
0·1815	0·125	0·0227	23·33	12·4	0·498	91·0	3·85	do.	6
0·174	0·125	0·02175	30·0	15·6	0·52	110·5	3·68	Time up	3
0·184	0·125	0·02275	30·0	16·16	0·539	116·25	3·18	do.	2
		0·02222							
To Remove Maximum Weight per minute.									
0·335	0·125	0·0418	30.0	12·2	0·407	165·75	5·53	Time up	3
0·349	0·125	0·04365	30·0	11·6	0·390	160·0	5·3	do.	1
0·346	0·125	0·04325	21·666	8·51	0·393	120·75	5·58	Tool failed	5
0·329	0·125	0·0412	18·25	7·18	0·393	95·25	5·22	do.	6
0·327	0·125	0·0408	27·0	10·25	0·38	142·25	5·28	do.	7
0·345	0·125	0·0432	30·0	11·75	0·392	164·0	5·47	Time up	4
0·340	0·125	0·0425	30·0	12·10	0·403	166·75	5·558	do.	2
		0.04234							



Area of cut. *(Cut by traverse.)*

FIG. 4.—VARIATION OF CUTTING STEEL, WITH AREA OF CUT—CAST IRON.

simple a character, but the following linear expressions give speeds which may probably be attained as a maximum :—

For soft cast iron $v = 115 - 13a$.

For medium cast iron $v = 63 - 858a$.

For hard cast iron $v = 40 - 400a$.

Taking in all six cases those trials only in which the tool ran for the whole time specified, and at the highest speed of any tool, the following Table (XIX.) has been prepared of the maximum speeds attained for the various cuts employed, as already depicted in Figs. 3 and 4.

In the last column has been given the weight of cuttings removed per minute for each cut and for each material. This quantity has been plotted in Fig. 5 on a base of area of cut, and shows how very greatly the weight removed increases as the cuts become heavier.

It further appears that heavy cuts will be much more economical in power; for the waste work is a much larger proportion of the whole work required at light cuts than at heavy ones. It is probably this fact which has given rise to the commonly accepted opinion that the cutting stress increases with the speed (as instanced by the objections of workmen to increase cutting speeds on account of the anticipated springing of the work), contrary to the results of these trials, which rather show the reverse to be the case. In soft steel, for example, the average horse-power required for actual cutting at $\frac{1}{16}$ in. by $\frac{1}{16}$ in. was 3, whilst at $\frac{3}{8}$ in. by $\frac{1}{8}$ in. it was 15. The friction horse-power of lathe and countershaft was about $2\frac{1}{2}$ h.p. The weight removed was about 105 lbs. and 445 lbs. per hour at the light and heavy cuts respectively, so that the weight removed per gross horse-power hour was 19·1 lbs. for the light and 25·3 lbs. for the heavy cut. Neglecting frictional loss, these figures would have been 35 and 29 respectively.

In the case of cast-iron, the gain in power at the heavier cuts is still more conspicuous. Here the effective horse-power was 1·7 and 5·5 at the $\frac{1}{16}$ by $\frac{1}{16}$ and $\frac{3}{8}$ by $\frac{1}{8}$ cuts respectively; the waste horse-power being about 2. The weights removed were 42 lbs. and 198 lbs. per hour (as seen

Table XIX.

SOFT STEEL (WHITWORTH FLUID COMPRESSED).

Intended Cut and Traverse.	Actual Area of Cut.	Max. Speed of Non-fails.	Weight Removed.
Inches.	Sq. Inches.	Feet per min.	Lbs. per min.
$\frac{1}{16} \times \frac{1}{16}$	·00325	149·2	1·72
$\frac{1}{16} \times \frac{3}{16}$	·0106	111·0	4·137
$\frac{3}{16} \times \frac{1}{8}$	·0215	74·0	5·28
$\frac{3}{8} \times \frac{1}{8}$	·0401	54·5	7·35
MEDIUM STEEL (FLUID COMPRESSED).			
$\frac{1}{16} \times \frac{1}{16}$	·00225	109	1·008
$\frac{1}{16} \times \frac{3}{16}$	·0114	80	3·17
$\frac{3}{16} \times \frac{1}{8}$	·02275	51·4	3·88
$\frac{3}{8} \times \frac{1}{8}$	·0418	39	5·53
HARD STEEL (FLUID COMPRESSED).			
$\frac{1}{16} \times \frac{1}{16}$	·00381	56·2	0·7
$\frac{1}{16} \times \frac{3}{16}$	·0124	41·20	1·708
$\frac{3}{16} \times \frac{1}{8}$	·0219	30·8	2·3
$\frac{3}{8} \times \frac{1}{8}$	·0452	20·8	3·092
SOFT CAST-IRON.			
$\frac{1}{16} \times \frac{1}{16}$	·0039	109	1·3
$\frac{3}{16} \times \frac{1}{16}$	·0124	99·5	3·617
$\frac{1}{16} \times \frac{1}{8}$	·01575	72	3·1
$\frac{3}{8} \times \frac{1}{8}$	·0459	55·5	7·458
MEDIUM CAST-IRON.			
$\frac{1}{16} \times \frac{1}{16}$	·00331	59·7	0·69
$\frac{3}{16} \times \frac{1}{16}$	·0115	49·0	1·73
$\frac{1}{16} \times \frac{1}{8}$	·0227	33·1	2·23
$\frac{3}{8} \times \frac{1}{8}$	·0446	24·35	3·32
HARD CAST-IRON.			
$\frac{1}{16} \times \frac{1}{16}$	·00359	38·6	0·47
$\frac{3}{16} \times \frac{1}{16}$	·01173	31·9	1·183
$\frac{1}{16} \times \frac{1}{8}$	·02025	25·0	2·842
$\frac{3}{8} \times \frac{1}{8}$	·0459	22	3·2

in Fig 5), and the weights per h.p.-hour were therefore : 11·35 lbs. at the light cut, and 26·5 lbs. at the heavy cut.

These results are of general application, and show that not merely can more material be removed in a given time with a heavy cut at its proper speed than with a light cut at the highest speed which the new steels can take, but that this can be done at a smaller expenditure of gross power per ton of shavings removed.

In Fig. 6 are seen curves co-ordinating the highest cutting speeds obtained with the leading factor in the chemical composition of the materials operated upon. For steel these speeds are plotted on a base of carbon contents, with which they show a regular variation.

(To be concluded.)

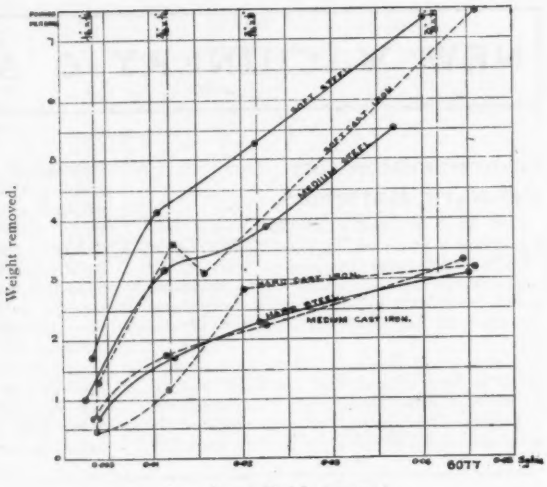


FIG. 5.—RELATION BETWEEN WEIGHT REMOVED PER MINUTE AND AREA OF CUT.

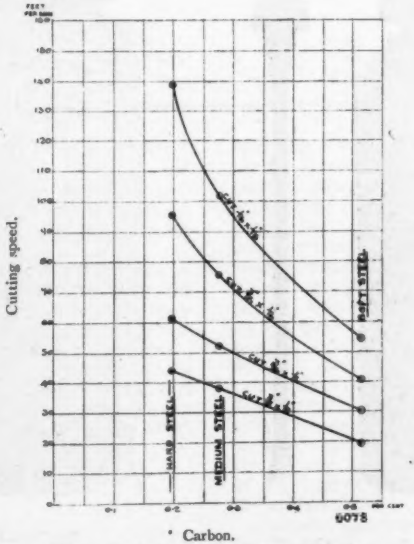


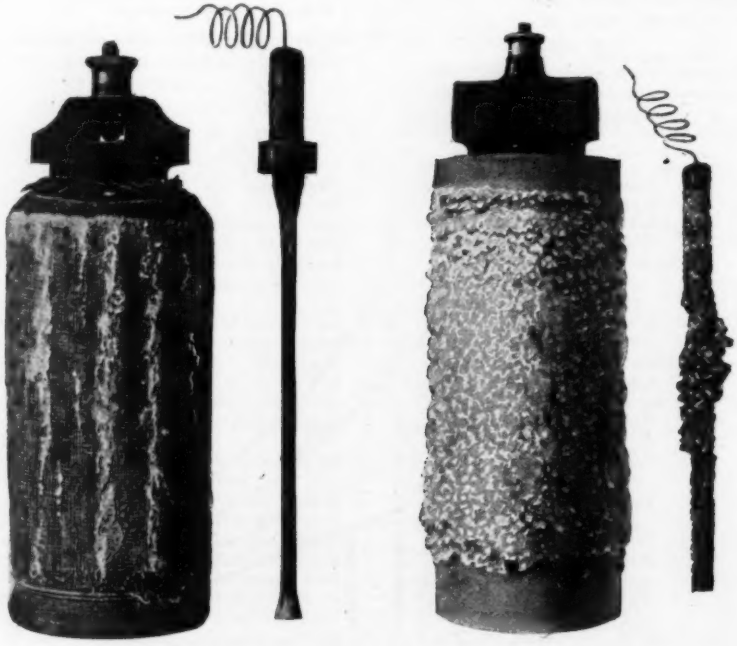
FIG. 6. VARIATION OF CUTTING SPEED WITH CHEMICAL COMPOSITION.

NEW MACHINERY & APPLIANCES.

Improvements in Primary Batteries.

WE have received from Le Carbone (late Lacombe & Cie.), of 17, Water Lane, Great Tower Street, some samples of cells of the zinc-carbon type in which some improvements have been embodied, with a resulting increase in the efficiency and life of the cell.

The latest addition to the series manufactured by Le Carbone is of the sack type, in which the usual porous pot containing the depolariser and carbon plate is replaced by a canvas sack, into which is packed a special depolariser. The advantage of this arrangement is that no crystals are formed. The excitant is an ordinary sal-ammoniac solution. The cell is made in three sizes, as shown in the under-mentioned table, and the positive element consists of either a zinc rod, as in the ordinary Leclanché type; or a circular zinc, as in the Bunsen cell, may be used, the internal resistance varying accordingly. This, as will be seen from the table, is given, in the case of size No. 3 as ·35 ohm when the circular zinc is used, and ·60 ohm in the zinc-rod type. Tests made on one of these cells in our office gave results which nearly coincide with these figures—viz., circu-



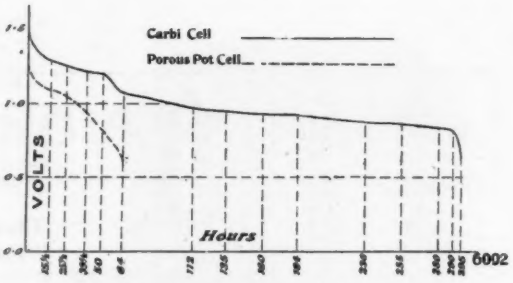
THE "CARBI" SACK. POROUS POT.

THE APPEARANCE OF THE "CARBI" SACK AND ORDINARY POROUS POT AFTER THE COMPARATIVE TEST, THE CURVES OF WHICH APPEAR ON THE PAGE OPPOSITE.

lar zinc type, ·33 ohm; zinc-rod type, ·61 ohm; and the e.m.f. at 1·58. In testing the e.m.f., however, it may be stated that a Daniell cell, arranged according to Prof. Flemings' method, was used as a standard, which may account for the apparent difference of ·02 volt.

The life of the sack cell is much longer than in the case of the ordinary porous pot type, as may be seen from the accompanying curve supplied to us by the makers.

This curve shows the results of a comparative test made with a No. 2 "Carbi" cell and a No. 2 porous-pot cell, both being closed through a resistance of 10 ohms. A drop in voltage to ·65 took place in the one instance in 295 hours, and in the latter in 64 hours.



CURVES SHOWING THE DROP OF E.M.F. OF A "CARBI" CELL AND AN ORDINARY POROUS POT CELL IN CONTINUOUS WORK ON A CIRCUIT OF 10 OHMS.

	No. 1.	No. 2.	No. 3.
Size of negative element.....	180 × 60 mm.	165 × 55 mm.	140 × 50 mm.
,, circular zinc	180 × 80 mm.	160 × 75 mm.	140 × 70 mm.
,, zinc rod	200 × 10 mm.	180 × 10 mm.	160 × 10 mm.
,, glass jar	185 × 100 × 100 mm.	165 × 95 × 95 mm.	155 × 90 × 90 mm.
E.M.F. (volts).....	1·6	1·6	1·6
Internal resistance (ohms)			
Circular zinc.....	0·15	0·25	0·35
Zinc rod	0·30	0·45	0·60
Charge of sal ammoniac	5 ozs.	3½ ozs.	3 ozs.

The Nos. 1, 2, and 3 sizes of the "Carbi" sacks fit the three regular sizes of the Leclanché-type glass jars, so that their adoption in place of ordinary porous pots involves no alteration in boxes or fixtures made for the latter.

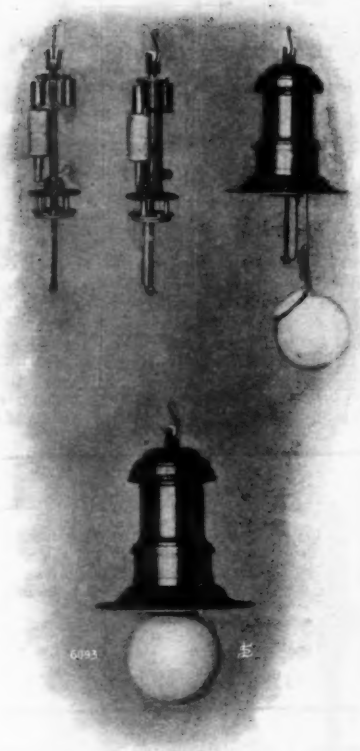
The "Carbi" sack cell is being made in a hermetically sealed type for use with testing sets, medical appatatus, and in cases where a small current at high voltage is wanted. For electric igniters, alarms, etc., the cell is sealed in such a manner as to prevent any leakage of the electrolyte, this being introduced into the cell through an orifice in the cover. This orifice is afterwards closed by a screw tin stopper.

The Meridian Electric Arc Lamp.

A RECENT opportunity was afforded us of inspecting a new arc lamp, which has one or two interesting features, the chief of which consist in the simplicity of its construction and the frame on which the mechanism of the lamp is erected. The latter consists of a base and a top plate united by two vertical bars of T section, all of which are cast in one piece in either brass or malleable iron. The globe-cover is provided with two or more pillars, which are also all in one casting, and is secured to the base plate of the frame in a simple manner. Through one of the pillars a bolt, insulated from the globe-cover, is passed, which serves to carry the bottom carbon-holder. The upper carbon-holder is fixed in a slide moving in the guides formed by the T section pillars of the main frame.

The regulating mechanism consists of the usual series and shunt solenoids, the coils of which are supported by arms projecting from the guide pillars, and cast with them; while the solenoid cores are connected to the ends of the rocking-frame, mounted on pivots to the guide pillars.

Pumping or jumping is entirely prevented by the introduction of a specially-designed dashpot or cushioned cylinder fixed to the top plate of the frame centrally with the



THE MERIDIAN ARC LAMP.

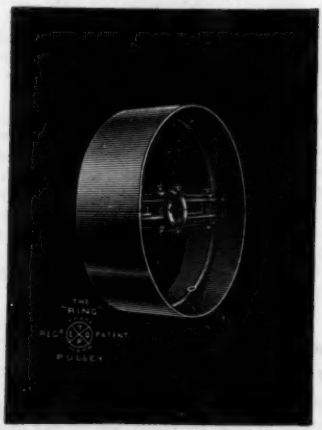
series coil, a plunger working in the cylinder being connected to the series coil. An inspection of the photographs will show that the working parts are reduced to a minimum. The globe-fixing device is extremely simple, and being arranged above the highest position of the arc, no shadows are cast by means of it.

The globe is removed by simply turning two thumbscrews which swing back, thus allowing the globe to be lowered until supported by the globe chain, which leaves both hands entirely free for replacing carbons, etc. The case, which is insulated from the lamp, is constructed of copper throughout, and is utilised to protect the lamp terminals from wear without the addition of a weather hood. The lamp is constructed for working currents of from 3 to 8 amps., although the most satisfactory and economical results have been obtained from the 4·5-amp. direct-current lamp, and a 5·5-amp. alternating-current lamp. The makers, The Crathorne & Green Mfg. Co., state that, taking as a basis of comparison 8 and 16-candle-power incandescent lamps of good quality, the 4·5-amp. lamp gives light equal to 2,000 candles at an electrical expenditure of ·45 B.T.U. per hour.

The Patent "Ring" Pulley.

THE pulley we illustrate below has the boss, arms, and inner ring cast in one piece. It is then split in halves, the irregularity of the fracture making a close and interlocking joint when the halves are bolted together. The boss is then bored, and the ring turned on its face to afford a true surface, on to which the wrought-iron rim is riveted. It is found that the combination of the ring with the two arms and the close joint gives great strength combined with lightness, while the turned ring secures a true-running pulley.

The makers—the "Unbreakable" Pulley and Mill-gearing Co., Ld., West Gorton, Manchester—are building all their pulleys of 10-in., 12-in., 14-in., 15-in., 16-in., and 18-in. diameter on this "Ring" principle, using two rings for pulleys over 10 ins. wide. They claim lightness, strength, convenience, true running, and good appearance, as compared with either the cast-iron or wrought-iron pulley of ordinary make, or with wood pulleys. In comparison with the latter, a great advantage in the "ring" construction is the absence of the air-fanning caused by the wide arms of the wood pulley.



SMALL "RING" PULLEY.

ENGINEERING ABSTRACTS.

LIST OF PUBLICATIONS REGULARLY REVIEWED.

Amer. Engin. & Rlrd. Jnl.	American Engineer and Railroad Journal	NEW YORK.....	20 *cts.*
Amer. Machst.	American Machinist	NEW YORK	-/4
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Ann. Ing. Gand	Annales de l'Association des Ingénieurs de Gand	BRUSSELS	*f.*2.50
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Jnl Am. Soc. Naval Engr.	Journal American Society of Naval Engineers	WASHINGTON...	$5'00 p.a.
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Jnl. Assoc. Eng. Soc.	Journal of the Association of Engineering Societies	PHILADELPHIA, U.S.A.	...
Jnl. Franklin Inst.	Journal of the Franklin Institute	PHILADELPHIA, U.S.A.	30 *c s.*

Jnl. I. E. E.	Journal of the Institution of Electrical Engineers	London	Varies from 1/6 to 7/6
Jnl. Iron & Steel Inst.	Journal of the Iron and Steel Institute	London	16/- per vol. (two annually)
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Zeitsch. Elektrotechnik.	Zeitschrift fur Elektrotechnik	Vienna	p.a. 20 *mks.*
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Any of the above-mentioned publications can be obtained on application to Messrs. Williams & Norgate, Henrietta Street, Covent Garden, London, W.C.

MATERIALS and MEASUREMENTS.

Tests of the Efficiency of Hoisting Tackle.

For the purpose of gaining information as to the efficiency of hoisting tackle, an extended series of tests was made recently at the Pencoyd plant of the American Bridge Co., with standard types of blocks, and various combinations of manila and wire rope. The tests were arranged so as to reproduce as nearly as possible actual conditions under which hoisting tackles are used in the field. An eye-bar testing machine of 300 tons capacity and a vertically-moving hydraulic crane were used in making the tests. The load on the machine

TABLE I.—EFFICIENCY OF TACKLE WITH TWO SNATCH BLOCKS.

Rope.	Parts of line.	Efficiency Percentages. Tested. Lifting (mean).	Tested. Becket mean pull.	Calculated. Lifting.	Calculated. Becket pull.
1¼″ manila, $C = 0.46$	4	57	48	60	58
	6	52	53	53	53
	7	49	44	50	45
1½″ manila, $C = 0.40$	4	50	49	56	55
	7	46	43	47	42
	9	47	38	42	36
1⅝″ manila, $C = 0.38$	5	45	49	47	45
	7	41	40	42	37
	9	39	34	37	31
2″ manila, $C = 0.34$	7	41	36	40	36
	9	37	38	35	30
¾″ wire, $C = 1.8$	5	49	41	...	...
	7	49	44	55	56
	9	54	48	50	49
	13	45	52	42	37

and the pull exerted by the crane, were taken from their respective mercury pressure-gauges. The results are shown in Table I. The tested efficiency for straight lifts is $\frac{W}{n P}$; where W = load on machine, n = number of parts of line carrying load, and P = pull of the crane. For the becket pulls, in which the machine is pulling against the crane, an analogous value for efficiency is $\frac{n' P'}{W'}$; where W' = pull of the machine, n' = the number of parts of line, and P' = the resistance of the crane. Under field conditions a lead line is frequently snatched a number of times before reaching the engine. It was desired, therefore, to obtain results of the tests, free from the influence of the two snatch-blocks used, and involving only the parts of the line holding the load, of which the first should be considered the lead-line. For this purpose the efficiencies of the combinations tested were worked out by Weisbach's formula:

$$\frac{1}{K} = \frac{1}{1 + C\frac{d_2}{r} + 2\sigma\frac{P}{r} sin.\ L},$$

in which d = diameter of rope; r = distance from centre of pulley to centre of rope; P = radius of sheave pin; $2L$ = arc of contact of rope on sheave; σ = coefficient of journal friction = 0·08; C = empirical constant. The efficiency of the movable pulley, for forward motion, or lifting is $\frac{1 + K}{2K}$. For reverse motion, or becket

TABLE II.—CAPACITY AND EFFICIENCY OF TACKLE WITHOUT SNATCH BLOCKS.

Rope.	Parts of line.	Lift per unit pull in lead line.	Efficiency Percentage.
1¼″ manila	2	1·92	96
	3	2·68	89
	4	3·37	84
	5	3·95	79
	6	4·48	75
	7	4·92	70
1½″ manila	2	1·91	96
	3	2·67	89
	4	3·36	84
	5	3·93	79
	6	4·45	74
	7	4·89	70
	8	5·28	66
	9	5·61	62
1⅝″ manila	3	2·64	88
	4	3·30	83
	5	3·84	77
	6	4·33	72
	7	4·72	67
	8	5·08	64
	9	5·37	60
2″ manila	5	3·87	77
	6	4·37	73
	7	4·78	68
	8	5·14	64
	9	5·45	61
¾″ wire	3	2·73	91
	4	3·47	87
	5	4·11	82
	6	4·70	78
	7	5·20	74
	8	5·68	71
	9	6·08	68
	10	6·46	65
	11	6·78	62
	12	7·08	59
	13	7·34	56

pull, it is $\frac{2}{1+K}$. Different values of C were derived from the tests for the different sizes of rope, and the efficiencies of the several combinations were computed. The results are shown in Table II.—**S. P. Mitchell, M. Am. Soc. C.E.,** *Proc. Am. Soc. C. E. Vol. XXIX., No. 6,* pp. 584–588.

A new German Electrical Oil-Testing Apparatus.

A NEW electrically operated oil-testing apparatus has recently been brought out by the Elektricitats-Actien-Gesellschaft, of Frankfort-on-the-Main, which is of more than passing interest. It is possible with this oil-tester to accurately determine the frictional co-efficient of different grades of oils at varying temperatures. It consists of a short length of shaft running in a bearing of the ring-lubricated type, and carries a heavy flywheel at each end which produces the ordinary pressure on the bearing. A pin-coupling is provided on this shaft in order that the motive power can be uncoupled at any moment while running. The apparatus is designed to be driven either by an electric motor, or by mechanical means, or by hand. For laboratory purposes, the machine is arranged with flywheels for different bearing pressures and an exact device for measuring the speed. When electrically driven, the apparatus is equipped with a motor having an output of about $\frac{1}{4}$th h-p., which operates at a speed of 1,800 revolutions per minute. The motor is set upon a common base-plate with the oil-testing machine, and drives the latter by means of a pin-coupling. The machine is of similar construction, having a suitable coupling for disengaging the motive-power at the proper time. When testing a sample of oil, about $\frac{1}{2}$ pint of the lubricant is placed in the bearing and the motor is started, the flywheel shaft being run at full speed for a short time, when the motor is disconnected by means of the coupling, allowing the tester to continue running until it comes to rest. It is only necessary to note the time required for the apparatus to come to rest in order to compare the lubricating qualities of the various samples. When another sample of oil is to be tested, benzine is passed through the bearing, and a blast of air is allowed to pass through as well, to dry it out. This electrical testing apparatus is fitted with electrical resistance coils for warming the bearing to any desired temperature. With the mechanically-driven oil-testing machine tubes are provided in the oil reservoir, through which hot water may be passed, and these tubes can also be used for cooling by passing cold water through them at any desired temperature.—**Frank C. Perkins,** *Machinery, Vol. X., No. 2,* p. 80.

ENGINEERING PHYSICS.

Radio-Activity.

IN this paper the author begins publication of the substance of a series of lectures delivered on this subject at University College, London. The subject itself dates from the discovery of X-rays in 1895, and as the Becquerel rays, which came next, have somewhat similar experimental properties, the author begins by considering the X-rays, tracing the historic connection between them and their successors, and showing that cathode rays, which consist of discrete particles of excessively small size travelling with enormous velocity and carrying a negative charge, are the cause, and the anti-cathode is the source, of the X-rays, which are the ether pulses resulting from the sudden stoppage of the cathode rays. After relating the history of the discovery of uranium radiation by Prof. Becquerel, the author goes on to describe the work of the Curies, which resulted in the discovery of radium and polonium and the examination of their properties Apart from the discovery of these elements itself, the most remarkable feature of the work of Mme. Curie was her conclusion—arrived at before the new elements had been found—that radio-activity is an atomic property. The author points out that, if we except *inertia*, there is only one other atomic property, viz., *weight*, which is the only property that can be universally used as the basis of chemical analysis. Radio-activity, however, is fitted in every way to be a property upon which a method of quantitative and qualitative chemical analysis could be based.—**F. Soddy,** *Electrician, Vol. LII., No. 1,* pp. 7–10.—*W. C. H.*

Radio-Activity.

THE second instalment of Mr. Soddy's lectures on this subject. Radium has so far only been found in minerals containing uranium, but many of these have too low an activity to repay extraction, and practically the whole of the supply comes from the Johanngeorgenstadt and Joachimsthal ores. From two tons of the latter ore Mme. Curie obtained a few hundredths of a gramme of pure radium chloride and a few tenths of a gramme of much less active material. Giesel obtains about 0·25 gramme from one ton of residues. The author describes the method of treatment of the residues from the Joachimsthal ores, worked out by Debierne Radium shows its relationship to the other alkaline earths by the beautiful red flame coloration given by its salts. Its atomic weight has been determined, a mean of three determinations of the purest sample giving the value 225. This makes it the third heaviest element known, the two above it being thorium 232, and uranium 238. These three elements are chemically dissimilar, radium being divalent like barium, thorium tetrevalent like tin, and uranium hexavalent like tungsten; but the author says "it is surely not merely a coincidence that the three elements distinguished by their radio-activity should possess the three heaviest atomic weights." The most remarkable property of radium is its ceaseless emission of rays, some having great penetrative power. Rutherford has shown that the greater part of the radiation consists of the projection of atoms of matter with a speed of about 20,000 miles per second, a velocity which matter has never before been known to attain. In addition there is an emanation given off, whose absolute amount is so small that it has not yet been directly perceived, but which possesses enormous energy whose effects are readily observed. Radium gives off heat to the extent of 100 gramme-calories per gramme per hour. Apart

from these and other unique properties, there is no essential difference between the radio-activity of radium and that of uranium, and radium itself behaves chemically as a normal element and fills up a vacant place in the periodic law as the heaviest member of the alkaline-earth group. Polonium and actinium are two other new radio-active bodies derived from pitchblende; so far they have only been detected by their radio-activity, as no sufficient quantity has been obtained to give a spectrum reaction or other evidence of their presence. Polonium resembles bismuth, and has not yet been obtained free from that metal. Its radiation comprises only the α or non-penetrating rays, the penetrating β-rays being entirely absent. In this respect it differs from the other radio-active bodies. Again, its radio-activity is not permanent but decays slowly with lapse of time, falling to half its original value in about nine months. Actinium, like radium, gives penetrating rays deviable in a magnetic field, and also gives a characteristic emanation capable of producing temporary activity upon objects in the neighbourhood, but distinguished from that of radium and thorium by a more rapid rate of decay than either of the others. Giesel has also described a substance which he calls the "Emanation Substance from Pitchblende," and which appears to be identical with actinium, discovered by Debierne. There are thus five permanently radio-active substances known—uranium, thorium, radium, polonium, actinium. The peculiar radio-active properties of these bodies is best seen in the following table :—

Substance.	α-rays.	β-rays.	γ-rays.	Radio-active Emanation.	Imparts activity to surrounding objects.
Uranium ...	Yes	Yes	Yes	No	No
Thorium ...	Yes	Yes	Yes	Yes	Yes
Radium ...	Yes	Yes	Yes	Yes	Yes
Polonium ...	Yes	No	No	No	No
Actinium ...	?	Yes	?	Yes	Yes

The radio-activity of uranium and thorium may not be a specific property of these elements, but may be due in each case to specific new elements not yet recognised but contained in all uranium and thorium preparations to an invariable extent. —**F. Soddy,** *Electrician, Vol. LII., No. 2,* pp. 43-45.—*W. C. H.*

Entropy.

THE author of this paper finds in the recent controversy on this subject corroboration of his own long-entertained conviction that the ideas and processes of thermo-dynamics stand in need of greater precision than that which generally characterises the definitions and explanations in the text-books, and he thinks that Mr. Swinburne has done good service by raising the discussion. In this paper the author dwells upon some of the points which usually lack clearness, such as the loose use of the terms reversible and irreversible as applied to cyclic processes, and the confusion between the working substance and the bodies constituting the sources or sinks of heat. After pointing out that change of entropy has been too exclusively identified with the working substance, he considers the case of an actual, and therefore irreversible, cycle, and shows that the effect of irreversibility is to increase the entropy of the whole system of bodies considered. At the close of the paper the subject is briefly considered from the point of view of waste of available energy—that is, the utmost amount of work that can be obtained from a system of reservoirs of heat, the temperature of the coldest being θ_0.—**A. Gray,** *Proc. Roy. Phil. Soc. Glasgow, Vol. XXXIV.*, p. 116.—*W. C. H.*

A Suggested Hydraulic Unit.

THE author suggests the introduction of a new unit to represent "one cubic foot of water per minute under a head of one foot." This unit would be equal to 62·3808 ft. lbs., or 0·00189 h.p., or 1·40994 watts. An analogy can be drawn between this unit and the watt, as the head in one is similar to volts in the other, and the cubic feet of water per minute takes the place of amperes in the other. Denoting this unit (or its equivalent value, 0·00189 h.p) by K, then the horse-power of water is given by the formula

$$\text{H.P.} = \frac{\text{Cub. feet of water per min.} \times \text{head in feet}}{K}$$

and K for efficiency $x = \frac{52{,}900 \cdot 8}{x}$. The author works out an example in which he uses this unit, and adds a table giving values of K in the first equation above for efficiencies ranging from 50 to 94 per cent. These values are based on water of spec. grav. 1, in which condition 1 cub. ft. of water weighs 62·3808 lbs.—**R. L. Montagu,** *Elec. Review (N. Y.), Vol. 43, No. 14,* p. 465.—*W. C. H.*

CONSTRUCTION.

Novel Method of Bridge Erection.

THE Frans bridge connects the city of Villefranche with the left bank of the River Saone, and consists of two shore spans of 45·86 m. (150·4 ft.), carried on two masonry piers and shore abutments. In erecting the two shore spans of the bridge, the contractors feared to use falseworks on account of the danger from floods. They therefore decided to erect each shore span practically complete on its respective bank of the river, and then to push it endwise out over the channel until its forward end rested on the river pier. The shore span complete, except for some of its secondary members and a part of its floor system, was erected on shore with each of its main girders resting on two sets of rollers. One set of rollers for each truss was located on the abutment, and the other set was placed 15 m. (49·2 ft.) inshore. Each set of rollers consisted of two pairs of rollers staggered in plan. Each pair of tandem rollers was held in a rigid I-beam frame, and this frame was

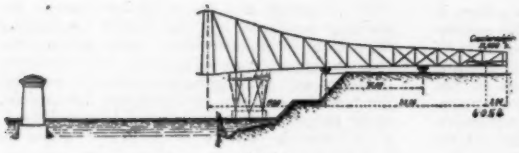


FIG. 1.

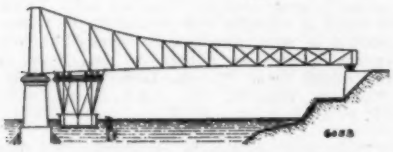


FIG. 2.

BRIDGE ERECTION.

supported on the plunger of a hydraulic jack. A hand-pump was connected with both pairs of rollers, and provided for raising and lowering them by pumping water into the cylinders of the jacks. Fig. 1 shows the span mounted on rollers ready for launching. To launch the span a winch was placed on it and chains led to an anchor on the abutment. The spans were shoved forward a distance of 17 m. (55 76 ft.), for one and 19 m. (62·32 ft.) for the other, without any support for the outer ends. At these points a barge carrying a staging was floated under the overhanging end, and the load taken by means of a hydraulic jack until the barge had settled so that its displacement balanced the weight, which was then taken by screw-jacks. The span was then forced forward by the winders until the increased overhang made a second adjustment of the screw-jacks necessary. This was accomplished by means of the hydraulic jack, and the movement of the span was continued until its end rested on the pier, see Fig. 2. The centre span was erected by building outward from each pier in the usual manner. — **A. T.**, *Génie Civil, Vol. XLII., No. 1116*, pp. 417-420.

Efficiency of Concrete Mixing-Machines.

CONCRETE mixing-machines are of two general types—batch mixers and continuous mixers. In the first type may be included the following: (1) A revolving drum fitted inside with deflectors. (2) A revolving drum formed by two cones with inside deflectors. (3) A revolving circular pan. (4) A revolving cylinder which mixes the concrete by revolving about its axis. This has been adapted to form a two-wheeled wagon, the cylinder being revolved by gearing from the axle, so that the batch of concrete may be mixed during transportation. (5) A trough of semi-cylindrical cross-section, with a longitudinal shaft carrying blades. These blades are set at an angle so as not only to mix the material but also to feed the mixture towards the discharge end. (6) A cubical box revolving about a horizontal axis, but having the corners through which this axis passes cut away to form openings for receiving and dumping the batch. Under the second class may be included the following: (8) An inclined chute fitted with pins. The materials are thrown in at the upper end, and slide down by gravity, being mixed by the deflections caused by the pins. (9) A series of funnels placed one above the other, and having in the mouth of each funnel an inverted cone forming a baffle. The upper funnel forms the hopper. (10) A long inclined box, square in section, revolving on its axis. The materials are thrown in at the upper end, and the concrete is discharged at the lower end. (11) This is somewhat similar to No. 10, but the box is cylindrical and is fitted with deflectors. (12) An open trough or closed cylinder fitted with a shaft on which are blades, to mix the concrete and feed it along to the discharge end. In the following table a comparison of efficiency is given :—

COMPARISON OF EFFICIENCY OF CONCRETE MIXERS.

	Values for Functions.							
Perfection.	40	25	10	5	5	10	5	100
Functions.	A	B	C	D	E	F	G	Total
Type of Mixer 1	25	25	5	5	5	7	3	75
,, 2	30	25	8	5	5	9	3	85
,, 3	30	25	8	4	5	9	5	86
,, 4	20	5	2	3	4	6	4	44
,, 5	20	25	6	5	4	6	4	70
,, 6	40	5	10	3	3	10	4	75
,, 7	40	25	10	5	5	10	4	99
,, 8	10	5	2	2	3	5	3	30
,, 9	10	3	1	1	4	5	3	27
,, 10	15	12	2	4	4	6	3	46
,, 11	15	12	2	4	4	6	3	46
,, 12	15	25	6	4	4	6	3	63

Values for perfection in the several functions :—

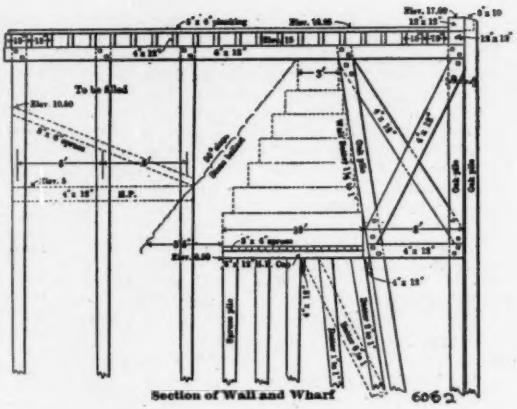
A—As producing results of a batch mixer	40
B—For control of water	25
C—For dry mixing	10
D—For receiving aggregates ...	5
E—For discharging concrete ...	5
F—For time in mixing	10
G—For self-cleaning	5
Total value as a mixer ...	100

C. Coleman, M. Am. Soc. C.E., *Eng. News, Vol. L., No. 9*, pp. 186–189.

Foundations.

IN some cases simple test pits will prove sufficient; in others it is advisable to make borings. Rod soundings are uncertain for any great depth, especially in clay, and in important cases it is well to supplement the borings with test piles. Very frequently the engineer may be uncertain as to the necessity for piling a foundation, and in such

cases it is well to remember that the cost of piles will add a very small percentage to the total cost of the structure, usually very much less than 5 per cent. It would be wrong to jeopardise the 95 per cent. for the sake of the 5 per cent. If the material round the heads of the piles is fairly hard it is safe to use concrete, but if it is quite soft and likely to remain wet, timber grillage should be used. At times the best form of grillage is a solid timber platform, which will cover and bear on every pile for its full area. Where piling is used to support masonry abutments or retaining walls through soft strata, it is important to look after the lateral as well as the vertical force. If the piles move forward horizontally the masonry will be injured. To counteract such movement provision should be made for riprap against the face of the piling and walls. When piles are not required it is good practice to spread the footings to cover the greatest area of natural earth practicable. Portland cement concrete is a very suitable material for bridge piers, abutments and retaining walls. The use of expanded metal for bonding purposes is frequently desirable. The placing of anchor bolts in engine foundations is necessary; their adjustment sideways to fit holes in the bed frames can be done in a simple and inexpensive way by placing vertical tubes of corrugated galvanised iron in the concrete and by providing cast-iron boxes to bolt the nuts at the bottom of the anchor rods they can be removed at any time. It is very difficult to divide the various kinds of earth and rock into classes that engineers will interpret as the same. As to the safe supporting loads of different classes of earth, the following is useful for general guidance:—"Make the base area as large as you can, within reason, when there is nothing to interfere, and when you cannot get an area as large as you would like, use all you can get; this rule not to be followed in extreme cases." Even with this, experience must teach what are and what are not extreme cases—extreme in the sense of very soft strata, which are not fit to place anything upon, or extreme in the sense of ridiculously small area, though of fair supporting power. — **G. B. Francis,** *Jnl. Assoc. Eng. Soc., Vol. XXX., No. 6,* pp. 336–342.



FAILURE OF A SEA-WALL

The failure of a Sea-Wall and its Reconstruction.

THE yard at the East Cambridge power station of the Boston Elevated Railway Co., has a frontage of about 471 ft. on a river and an area of 217,807 sq. ft. The yard is used for the storage of various kinds of material. During the autumn of 1901, about 12,000 tons of coal were piled upon the wharf in front of the boiler-house, while at the same time a pile of paving blocks extended for 50 ft. along the westerly face of the sea-wall. Under this load the sea-wall and wharf began to yield, and was pushed outward into the river about 12 ft. and downward about 6 ft., but the pier extending along the face of the wall prevented its total collapse. The excessive loading compressed the soft mud directly under the filling. This displaced the mud in front of it, which pushed out into the water, carrying piles, wharf and wall along with it. The piles under the wharf were not long enough to penetrate into the clay and so to offer the resistance necessary, while the short piles in the wharf offered only their individual resistances. In reconstructing the wall and wharf all the filling was excavated for a distance of about 16 ft., the old spruce wharf piles were cut off, and all the oak piles in front of the wall were pulled out. The piles under the old wall were left in, as the difficulty of pulling them was great. The new wall built was 10 ft. wide at the bottom, 3 ft. wide on top, and 12 ft. 6 ins. high, with a batter of 1½ ins. to the foot, ballasted on the back with quarry chips and the smaller stones from the old wall. For the foundation of this wall six rows of spruce piles, about 12 ins. at the butt, averaging 28 ft. long, were driven, the two rows next the face of the wall having a batter of 1 in. and 2 ins. to the foot, respectively, while a spruce pile, as nearly as possible to a batter of 6 ins. to the foot, was placed about under the centre of gravity of the wall and between the other rows of piles. The tops of these piles were capped with 6-in. by 12-in. hard pine, drift-bolted to piles with 1 in. bolts, and on these caps a flooring of 3 ins. by 6 ins. spruce planking was spiked. Outside the new wall three rows of oak piles were driven, those of the two outside rows being 40 ft. long, while those in the row next the wall were 34 ft. long, this last having the same batter as the wall. Tying each two rows of piles together, from the outside row of oak piles in front of the wall to the last pile driven back of the wall, were two girder caps, 6 ins. by 12 ins. by 34 ft. On these were drift-bolted 4-in. by 12-in. floor beams, on

which the 3-in. by 6-in. floor plank was spiked. The face of the wharf was built with a 12-in. by 12-in. stringer and rider cap, and had a fender cap 8 ins. by 10 ins. bolted between the fender piles. The oak piles were tied together by cross braces of 4 ins. by 12 ins., and two 4-in. by 12-in. low-water girders, all the timber used in wharf construction being hard pine. The Fig. shows a cross-section of the new construction.—**C. T. Fernald,** *Jnl. Assoc. Eng. Soc., Vol. XXX., No. 6,* pp. 343–350.

Experiments on Granite Square Stones for Bridge Joints.

From tests made on 21 specimens supplied from the *Weunsiedel (Bavaria) Granit-Gesellschaft*, it is inferred that the relation between the breadth b of the contact surface and the load p is $C=4\sqrt{\frac{2}{\pi}\alpha\left(1-\frac{1}{m^2}\right)\frac{P}{l}r}$

The invariability of the maximum pressure strain of the material would, for equal values of the coefficient of elasticity and the ratio of the longitudinal tension to the lateral contraction, result in the load P increasing proportionally with the radius of curvature. A fissure was observed for $r=250$ mm. at

$$P=\frac{100{,}000+92{,}500+94{,}800}{3}=\infty\ 95{,}800 \text{ kg.}$$

As, however, cracks are noted for $r=3{,}700$ mm. at $P=154{,}300$ kg., being about $\frac{1}{25}$th of the value to be anticipated in the case of proportionality with r, the author thinks the law stated by Hertz for the connection between P and r not to be in accord with the facts. This disagreement is accounted for by the fact that the destruction of the granite squares is produced not by the stress but by strain.—**C. Bach,** *Zeitsch. Ver. Deutsch. Ing., Vol. XLVII., No. 40, Oct. 3, 1903,* pp. 1436–1449.—*A. G.*

Moisture in Conduits.

The results of examination lead the writer to the conclusions: (*a*) seamed conduit, or socket-jointed conduit, should never be buried in plaster. At least, never in walls subject to action of weather, especially if these are of solid brick or stone. (*b*) Watertightness should be aimed at, at any rate, when conduit is laid on "sweaty" walls, under plaster or stone floors, and in draughty situations. (*c*) Conduits with insulated lining will probably be slightly less subject to rapid variations of temperature, and consequently condense less. For extremely damp situations and high voltages, conduit does not appear to the writer to be particularly applicable. Lead-covered watertight systems appear to have a great pull over conduit, although even lead is subject to corrosion by water. Wiring in damp places has hardly yet received the attention its importance warrants, and it ought to interest fire insurance people, especially in view of the higher voltages now becoming common. In this case we find the somewhat paradoxical result that water may cause fires indirectly, one case of this sort being a wire on which water dripped becoming gradually corroded and finally heating up. At present, no special means appear to be taken beyond putting in T-pieces at switch-blocks, and giving the conduit a dip, to allow the moisture to drain away anywhere. As far as the writer is aware, no special drain-taps, etc., are at present on the market.—**W. H. F. Murdoch,** *Electrician, Vol. LI., No. 12,* p. 501.

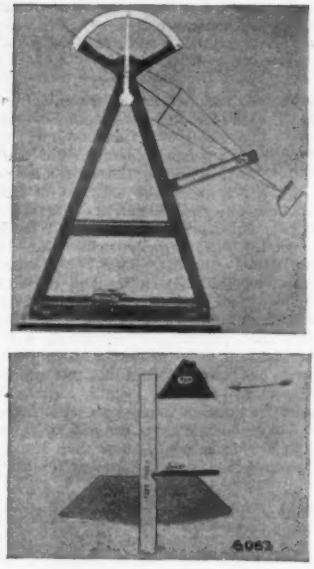
Oil Treatment for Leaks in Concrete.

In Fort Caswell, North Carolina, it has been found almost impossible to prevent unequal settlement and consequent cracking of the concrete. Various schemes have been tried to stop the leaking produced by the cracks, and finally a device was adopted which has resulted in a complete solution of the difficulty. It was noticed that water falling on the concrete surfaces near the guns, which had been coated with the oil used on the guns, was not absorbed. This led to a coating of the entire concrete mass with boiled linseed oil. Where large cracks occur, they are filled with cement grout, and the linseed oil is poured in as long as it is absorbed. There is formed in the crack a gum from the oil, which ultimately fills it to the top, after which the entire surface is coated with successive applications of the oil until it ceases to be absorbed. Previous to the trial of this method the two 12-in. emplacements were notably leaky, and for the purpose of experiment the worse of the two was selected and treated as above outlined, with the result that it was made perfectly water-tight. Since then all of the emplacements of the post have been treated similarly, and may now be considered water-tight. It is probable that it will be necessary to give a coating of oil, at least near cracks, when the concrete expands and contracts in the spring and autumn; but this will be comparatively inexpensive and take very little time. A gratifying result of this oil treatment is the prevention of the glare from the concrete surfaces, which heretofore has been particularly objectionable. The resulting colour is a brown, which is restful to the eyes and blends with the colour of the surrounding sand-hills, making the emplacements very difficult of detection from a distance.—*Report, Chief of Engineers U.S. Army, 1902; Eng. Rec., Vol. XLVII., No. 17,* p. 443.

METALLURGY.

Testing the Brittleness of Steel.

In a paper presented to the British Association the author urges the necessity for a "brittleness test" of steel, stating that the adoption of such a test, in addition to the usual tensile one, would in all probability lead to the avoidance of many cases of peculiar fracture. In actual working life many fractures of steel parts have occurred which are inexplicable by known chemical or standard physical tests, and the author's experiments show that an apparently ductile steel, as evidenced by the usual tensile tests, may, in fact, be exceedingly brittle. Attention has been drawn to this question of brittleness by M. Fremont, and Professor Arnold has also recently shown that "vibratory brittleness" in a steel cannot be detected by a tensile or bending



TESTING BRITTLENESS OF STEEL.

test. In conducting his experiments, the author, after considering the various impact testing systems, decided to adopt the pendulum type of machine, in which fracture of the test-piece is caused by one blow. This machine is shown in the accompanying figure, and as will be seen is composed of two stiff **A** frames bolted together, from the apex of which is suspended pendulum-wise a rod carrying the tup. If this rod is canted from the vertical a certain number of degrees and allowed to fall freely the weight describes an arc, and at the bottom of its swing has a certain amount of energy represented by the weight of the moving mass multiplied by the vertical equivalent of height of fall; further, if allowed to continue its path and expend its energy it will rise to a nearly corresponding height on the other side of the vertical position, the slight loss in height of rise being due to the friction of the moving parts. A test-piece fixed so that one free end intercepts the moving mass at the bottom of its swing will be fractured by the weight. The test-piece will absorb a certain amount of energy possessed by the tup, and the final height of the swing of the pendulum will be lessened, an amount which, transferred to equivalent foot pounds, gives the resultant energy absorbed by the test-piece. At the base of the **A** frame a small vice grips the test-piece, and is so arranged that lateral adjustment can be made to ensure impact taking place at the lowest point of the tup in its swing. It may be noted that the rod carrying the tup permits of adjustment up and down by means of a horizontal roller carried on two centres, an arrangement which also permits of the friction being checked on the scale. The latter may be corrected to remain constant by slightly adjusting one of the centre screws. The recording pointer is a light-balanced steel arm, which swings on one of the centre screws and is moved round the scale by a bent steel finger projecting from the pendulum rod and is left by it when the motion is reversed, thus recording the maximum height to which the tup has risen after breaking the piece. The scale over which the pointer moves is calibrated to read directly in foot-pounds of energy absorbed, a device leading to quick and accurate work. It has been found advisable to adopt one standard

No.	Material.	Energy at impact in ft.-lbs.	Energy absorbed by Test Piece.	Yield point, tons per sq. in.	Ultimate Strength, tons per sq. in.	Elongation % on 2 ins.	Contraction of Area %
4683 ...	Stud Steel	23	3·25	—	32·75	28·0	59·0
5165 ...	Steel from forging	23	2·5	18·6	33·36	33·0	48·0
5167 ...	,, ,, ...	23	2·2	20·47	39·26	28·0	42·2
5193 ...	,, ,, oil tempered	23	0·7	20·47	39·26	28 0	42·2
5192 A ...	Special Steel...	23	16·9	37·0	52·0	25 0	54·0
5192 B ...	,, ...	23	16·9	37·0	52·0	25·0	54·0
4989 ...	Steel from forging	23	0·9	14·8	30·8	30·0	38·6
5145 ...	,, ,, ...	23	3·5	14·4	25·7	39·0	59·0
5045 ...	,, ,, ...	23	4·8	13·2	28 7	32·0	—
5136 ...	Steel sample for bolts ...	23	0·6	—	34·1	21·0	50·0
20 Q ...	Special Steel	23	12·3	39 8	50·6	20·0	45·7
94 ...	,, ...	23	3·8	23·5	42·1	26·0	41·7
21 Q ...	,, ...	23	3·7	—	62·4	19·0	41·0
4617 ...	Stud Steel	23	6·9	—	31·0	30·0	67 0
4824 ...	Steel from small forging ...	23	2·8	14·4	25·4	40·0	63·4
5194 ...	Naval Brass	23	3·7	—	26·3	19·0	27·2
5195 ...	,, ...	23	5·5	—	30·3	28·0	55·0

size for all tests, as being most likely to give an accurate comparison of the brittleness qualities. The pieces used are 2 ins. in length, $\frac{3}{4}$ ins. wide, and $\frac{1}{8}$ ins. thick. The nick is V-shaped 0·05 ins. deep, and the radius at the bottom is about 0·01 ins. With a tup giving 23 foot-pounds of energy at impact, a specimen of these dimensions will be found to fracture at one blow even though of abnormally stiff steel. In the accompanying table some of the results yielded by this test are given, and are interesting, as showing how little bearing the tensile test has on the brittleness question. For instance, numbers 5045 and 4989 are both from similar forgings, they were tested in tension to specification, and, as shown, there is very little indication of any difference in quality. Under the brittleness test, however, 4989 fractured like a piece of cast-iron and absorbed only $\frac{1}{4}$th of the energy taken by 5045. A comparison of the brittleness tests with the corresponding tensile ones sheds much light on the brittleness question and goes to prove that many cases of failure may be traced to this cause.—**E. G. Izod,** *Engineering, Vol. LXXVI., No. 1969,* pp. 431–432.—*P. L.*

Iron Ore of Arctic Lapland.

In an interesting communication to the Lake Superior Mining Institute the author gives a description of the extent, quality and development of the ore deposits of Swedish Lapland. The ore won from the Gellivare district amounted in 1902 to 977,744 tons. This ore as mined is divided into the five following grades:—(A) Containing below 0·04 per cent. phosphorus and up to 68 per cent. iron; (B) Containing from 0·04 to 0·10 per cent. phosphorus and 68 per cent. iron; (C) Containing from 0·1 to 0·8 per cent. phosphorus and 65 per cent. iron; (D) From 0·8 to 1·25 per cent. phosphorus and 63 per cent. iron; (E) In the E grades are classed all the ores containing higher than 1·25 per cent. phosphorus and the content of iron is guaranteed at 61 per cent.—**C. S. Osborn,** *Mines and Minerals, Vol. XXIV., No. 3,* pp. 111–113.—*P. L.*

The Principal Iron-making Centres of the United States as Competitors.

The location and typical conditions of eight principal iron-making centres are described and a comparison drawn between the railway conditions of the States and Britain. The pig iron conditions of the two countries are worthy of note; thus a typical Pittsburg furnace using a 63 per cent. ore will produce 10,000 tons per month, and use in doing so about 17,000 tons of ore and perhaps 3,000 tons of limestone, or 20,000 tons of both materials. A typical English furnace of the Cleveland district will use 25,000 tons of calcined ore, or 35,000 tons of raw ironstone with 4,000 to 6,000 tons of limestone to produce the same quantity of iron. In other words, about twice the quantity of raw material has to pass through the English furnace in order to yield the same output as the American one. In the case of the West Coast furnaces the quantities of materials are relatively less than in the case of Cleveland, but they are still considerably greater than in American plants.—"*Special Correspondent,*" *Iron & Coal Trades Rev., Vol. LXVII., No. 1858,* pp. 1075–1076.—*P. L.*

Alloys used for Steel Making.

The author commences an examination of the alloys used for the production of special steels. These special steels possess characteristic features which fit them for some particular purpose: thus by the addition of certain alloys the tenacity and elongation of carbon-steel is improved, whilst others impart intense hardness to the metal. Taking nickel-steel first, experience has shown that the nickel is best added in the form of a ferro-nickel alloy, and the steel is conveniently made by the Open-Hearth Process. By this method no difficulty is found in alloying even very low percentages of nickel, and the ingots produced are perfectly homogeneous. Experience has further shown that this uniformity cannot be secured by using metallic nickel. Four samples of ferro-nickel on analysis were found to contain respectively 25, 35, 50, and 75 per cent. of nickel, the constituents other than iron were found to range between the following limits:

Carbon	...	...	0·75 to 1·00%
Silicon	...	...	0·20 ,, 0·30%
Sulphur	...	...	0·01 ,, 0·02%
Phosphorus	...	...	0·02 ,, 0·03%

Nickel-steel is largely employed in the construction of gun tubes, armour plates, shafts, and in all purposes where high tensile strength is required. In fact, forgings of steel containing from 3 to 3½ per cent. nickel, and 0·28 per cent. carbon, have a tensile strength 40 per cent. higher than nickel free steels of the same carbon content. A steel containing 36 per cent. of nickel is worthy of note; this alloy serves for the construction of chronometric apparatus, geodetic bases and compensated clocks. The expansion of this alloy is so very slight that it can scarcely be measured by the most delicate apparatus, and compensators made from it remain almost unaffected by temperature. Chromium is known to impart great hardness to steel and has therefore been utilised in the manufacture of armour plate and projectile steels. Modern armour-piercing chrome-steel projectiles will penetrate compound armour plates 10½ ins. in thickness, remaining practically unaltered in form, whilst projectiles of 13·5 ins. diameter when fired from a 63-ton gun will penetrate over 3 ft. of steel and wrought-iron. Chrome-steel also finds application in the manufacture of stamp heads, in the construction of safes and vaults, in the manufacture of tool steels, wire ropes, and so forth. These steels usually contain from 1 to 4 per cent. of chromium, associated with from 0·8 to 1 per cent. of carbon, but it seems that the addition of 15 per cent. chromium to a steel containing 0·4 per cent. carbon, produces the best mechanical properties. The chromium is added in the form of a ferro-chrome containing from 60 to 68 per cent. chromium associated with iron and decisive amounts of carbon. By means of the electric furnace, ferro-chromes may be obtained containing

70 per cent. chromium, and this form of alloy is employed by the Carnegie and Bethlehem steel companies for the manufacture of armour-plate steel. At the Krupp works ferro-chromes are obtained by the Goldschmidt method, in which metallic aluminium is used as the reducing and heat-producing agent. A more recent alloy is that of ferro-cobalt, which added to steel is expected to produce similar properties to those of nickel-steels. In one case a steel containing 1·8 per cent. of cobalt, gave in the unannealed condition a tenacity of 41 tons per sq. in., and an extension of 19 per cent. on 2 ins. After annealing the results were: tenacity 35 tons per sq. in., and extension 29 per cent. The fact has also been established that cobalt steels containing higher percentages than 1·8 are very malleable, and have a higher limit of elasticity than that possessed by carbon-steel. **Dr. J. Ohly,** *Mines and Minerals, Vol. XXIV., No. 3*, pp. 109–110.—*P. L.*

Tensile Tests of Mild Steel.

In the case of steel, the engineer relied on tests of samples for assurance that he was obtaining suitable material. It was important, therefore, that the information given by tests should be definite and comparable. Mechanical tests were for the engineer the most important, but as usually conducted they were not wholly satisfactory, and had to be supplemented. The object of the paper was to consider some conditions which affected the results of tests, especially as regarded the measurement of ductility. Ductility was probably the most important quality in the material for working purposes. Some conditions were then discussed. The time-effect was only negligible provided inertia-forces might be neglected. The method of gripping the test-bar and the form of fracture as affecting the results were discussed, and the influence of enlarged ends on the elongation. The effect of the position of fracture between the gauge-points was examined, and some numerical results were given. Next, the effect of small variations of cross section, which was greater than was ordinarily supposed, was shown. The total elongation was shown to consist of a general stretch, nearly uniform along the bar, and a local stretch. As geometrically similar bars deformed similarly, the percentage of ultimate elongation was the same in similar bars of the same material. The law of percentage of elongation in geometrically dissimilar bars was then examined, and it was shown that for bars of any given material, of gauge-length l and cross-section A, the percentage of elongation was given by the equation

$$e\% = \frac{c\sqrt{\text{A}}}{l} + b$$

where the first term on the right was the local and the second the general extension, c and b being constants. This equation was first verified by application to some results obtained by Mr. Barba on bars of varying gauge-length, cross section and form of cross section. The proportion of local to general extension in certain cases was determined. An account was then given of a series of tests on ship and boiler plates of different thicknesses, made for the Engineering Standards Committee. The results were first discussed by using plotted curves without assuming the elongation equation. Taking from the curves the elongations for bars of a standard form, the real relative ductility of these bars was found. This was compared with the elongations for bars of constant width such as were generally used in testing. It was shown that the elongations in the latter case were very misleading as to the relative ductility. In the case of similar bars the ductility decreased as the thickness of the plates increased. But the results on bars of constant width would lead to the conclusion that the thickest plates were the most ductile. The constants in the elongation equation were then given for the bars in each of six series of tests and for plates of ¼ to 1¼ in. thick, with a detailed comparison of the elongations calculated by the equation and observed in the tests. A further series of tests on plates with varying percentages of carbon was given. The constants c and b in the elongation equation decreased as the percentage of carbon increased. Lastly, a series of tests was made by Mr. F. C. Fairholme, of the Cyclops Steel Works, on short test bars cut from tires and axles. It was shown that the elongation equation was applicable to these short test-bars. The forms of short test-bars which could be used in such cases was discussed, and a very simple recommendation was made which would secure that in all such tests the elongations would be comparable. The question of quality figures for materials was then examined. It was pointed out that if quality figures were to be of value the tests must be made on similar test-bars, or the results must be reduced to equivalent results on similar bars. The values were examined of the quality figure for the whole of the tests described in the paper for test-bars of different areas of section. **Prof. W. C. Unwin. B.Sc., F.R.S.,** *Proc. Inst. Civil Engrs., Nov. 1903.*—*C. E. A.*

The Passive State of Iron.

In a paper presented to the American Electrochemical Society, the author discusses the practical application of the passive state of iron. Iron may be made to assume this condition by employing the metal as an anode in suitable electrolytes, and of such solutions are sodium nitrate, and various other soluble nitrates. On assuming the passive condition, the iron is not attacked by the anode products, but acts towards the solution as would an anode of platinum. Whilst this fact has been long known it has only recently met with industrial application. An improvement in the method of brazing bicycle parts, consists of dipping a portion of the frame to be brazed into a bath of molten spelter which effectually brazes the joints, leaving, however, an adhering coating of spelter on the outer walls of the tubing. This thin layer must be removed before the frames are enamelled, and an attempt was made to remove it by means of an electrolytic stripping process. Many trials of various

electrolytes were made, and it was found that the iron corroded more readily than did the copper which enters into the composition of the brazing spelter. The idea then occurred of making the iron more electro-negative than the copper by causing it to assume the passive condition, and on using the sodium nitrate solution it was found that the spelter could be completely removed, leaving the iron intact. This method of electrolytic stripping is now an important adjunct to the dip brazing method, and it may be applied equally well in removing silver, lead, tin and other metals from an iron surface. Nickel cannot be removed in this way, since nickel, as well as iron, assumes the electro-negative state. In stripping brass from iron the current should remove it at an approximate rate of one gram per ampère-hour, provided that all the current enters the solution from the brass and none of it utilises the iron as an anode surface. **C. F. Burgess,** *Amer. Manfr., Vol. LXXIII., No. 15,* pp. 521–2.—*P. L.*

Composition and Strength of Steam Cylinder Castings.

In order to arrive at a more certain knowledge as to the composition and strength of steam cylinder castings, 41 specimens supplied by 21 firms were examined, all of which were cast in the same way. The connection between the chemical composition of cast iron and its behaviour with regard to mechanical strains, has so far been known only as to some essential points. The following results are stated by the authors. Both the absolute and relative strengths are in the first place dependent on the percentage of silicon and the total percentage of carbon, the co-efficient of absolute strength being for high amounts of silicon the higher, the lower the total percentage of carbon present at the same time. Moreover, the total percentage of carbon may be the higher, the smaller the amount of silicon contained by the material. Sulphur has hardly any influence on the absolute strength, whereas appreciable effects are noted in the case of the transverse (flexion) strength. The resistance against shocks seems to be the higher the greater the ratio of the relative strength to the absolute strength; this shows the advantageous influence of low amounts of sulphur on the resistivity to shocks. Phosphorus does not exert any influence on the magnitude of the strength co-efficient. In the case of deflection experiments, the behaviour of the deflection curve is modified. Whereas the latter for higher amounts of phosphorus is nearly rectilinear as regards the (breaking) charge, the curves of material poor in phosphorus become gradually steeper, the increase of the deflection for equal increases in the load being greater in the case of higher charges than in that of low charges. A similar effect is observed in the case of bound carbon (upwards of 0·90 per cent.). The influence of phosphorus is much more striking in the case of shock experiments, whereas bound carbon seems to exert but a small influence in this respect, the resistance against shocks being not materially improved.

The average figures are given in the following table:—

Absolute strength	1961 kg., sq. cm.
Relative ,, ...	4081 ,, ,, ,,
Deflection before fracture	8·3 mm.
Height of fall of hammer	8·5 mm.

The chemical composition ranged between the figures given below:

Percentage of	Si	from 0·92%	to 2·13%
,,	Mn	,, 0·56%	to 1·21%
,,	P	,, 0·23%	to 0·69%
,,	S	,, 0·078%	to 0·123%
Total ,,	C	,, 3·36%	to 3·62%
Bound ,,	C	,, 0·63%	to 0·87%
,,	Graphite	,, 2·53%	to 2·86%

F. Wüst and P. Goerens, *Stahl & Eisen, Vol. XXIII., No. 19,* pp. 1072–1077.—*A. G.*

The Production of High Temperatures by Means of Thermite.

Thermite is the name given to a mixture of iron oxide and aluminium, both of which are in a fine state of division. The reaction taking place is that of the oxidation of the aluminium, which gives rise to a very high temperature and in turn effects the reduction of the iron oxide to metallic iron. Chemically the reaction may be expressed thus: $2\,Al + F_2O_3 = Al_2O_3 + 2\,F$. The iron so obtained is of exceptional purity, but obviously the method cannot compete with the ordinary reduction processes. In the case of the more costly metals, as chromium, manganese, nickel and cobalt, the method has some commercial value. In the production of these metals the ore in the form of oxide is mixed with finely divided aluminium, and the mixture placed in a Hessian crucible. On the surface is spread a layer of barium peroxide and aluminium termed the "kindling mixture." In the centre is placed a cartridge consisting of a pellet of the kindling mixture with a short strip of magnesium ribbon projecting. A match is applied to the latter, which evolves sufficient heat to start the reaction between the barium peroxide and aluminium, which in turn evolves sufficient heat to start the reaction between the oxide and aluminium. In this manner carbon free manganese, nickel, cobalt or chromium may be readily obtained. The application of thermite as a heat producer has so far been made to problems of welding, especially the welding of rails *in situ*, structural iron-work, pipes, etc. In using thermite as a heat producer the manipulation is practically the same. Usually the parts to be welded are surrounded at the point of junction with sand, firebricks, etc., to confine the heat, and the thermite is placed within this improvised furnace. **B. P. Caldwell,** *Jnl. Assoc. Eng. Socs., Vol. XXXI., No. 2,* pp. 57–62.—*P. L.*

PRIME MOVERS.

Blast-furnace Gas-engines.

The Lackawanna Steel Company are now putting in three plants for using blast-furnace gas, one of eight 1,000-h.p. engines to drive dynamos, and two others, including 16 2,000-h.p. engines, which are to drive blowing-engines. There has been a very eager struggle for improvement

in the design of large unit internal combustion engines during the past few years. The ordinary gas producer, the Mond process with recovery of ammonia, and the Pettibone-Loomis process, are being rapidly introduced. so that the gas-engine is forging ahead for central station work, for pumping plant, and miscellaneous purposes. One of the latest 4-cycle engines is that of the Nürnberg Company, of which the new valve gear is shown in Fig. 1. On the shaft is a cam *a*, which through the rod *d e* actuates the inlet valve through the lever *e f g*. This valve opens inward during the whole of the suction stroke. It is closed by the spring *F*. In the same valve case is a counter-balanced doubly seated valve, which permits the entrance on the one hand of gas and on the other of air in constant proportions. It is operated through the lever *m f l* and the rod *l k i*. The roller *i* of this rod is in contact with the surface of the lever *c b*, so that this mixture valve is also opened during the entire suction stroke. The governor acts by displacing the rod *l i*, so that the roller *i* is more or less distant from the fulcrum *c*. In this manner the mixture valve opens more or less according to the position of the governor. One of the most interesting of the European gas-engines is the Koerting double-acting 2-cycle engine, which has been selected by the Lackawanna Steel Company. The piston has a length about equal to the stroke of the engine, while the working cylinder has somewhat more than double its length. At both ends of the working cylinder are the inlet valves, which are operated by cams from the valve shaft. Besides this valve there is attached to the cylinder head only the small valve for starting the engine with compressed air. The engine has no exhaust valves. The working piston, when it occupies the position at the end of the stroke, uncovers a series of ports through which the products of the combustion may escape (Fig. 2).

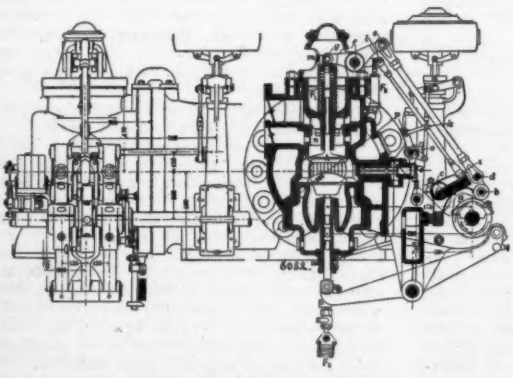


FIG. 1.—BLAST-FURNACE GAS-ENGINES.

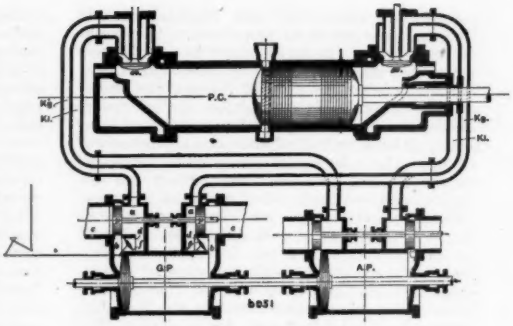


FIG. 2.—BLAST-FURNACE GAS-ENGINES.

The mixture of gas and air is supplied by two auxiliary pumps, located alongside the working cylinder. They are driven by a crank from the main shaft, and are operated by one rod. They are supplied with plain piston valves, so arranged that the rear part of the gas pump and the rear part of the air pump supply the rear inlet valve of the engine cylinder. **G. Kirchhoff,** *Jnl. Franklin Inst., Vol. CLVI., No. 2,* pp. 81–96.

Water-tube Boilers.

THE author takes a general view of the changes which have been made in order to overcome the defects appertaining to the cylindrical type of boiler. The velocity of the water through the tubes is much greater than in cylindrical boilers. In the Babcock & Wilcox boiler, if working under proper conditions, there is a "head" of 3 ft. 4½ ins., which gives a velocity of 14·7 ft. per sec.; but this is much reduced on account of friction. The velocity of water in the Belleville is less than this, owing to the constricted and tortuous passage through which it has to pass. A great deal has been said about the bad effects caused by salt water getting into water-tube boilers, but where the circulation is good, the tubes large and straight, salt water does but slight harm if the density is not allowed to increase too much. The pitting of the tubes in the upper elements of the Belleville may be due to superheated steam being decomposed, and not so much to the magnesium chloride splitting up and combining to form hydrochloric acid. The steam from some boilers, notably the Belleville, passes through a reducing valve, causing a more even pressure to be maintained, and therefore to some extent makes up for small steam space in the boiler. The steam, if perfectly dry on being reduced in pressure, would be slightly superheated, or if there were a certain percentage of water

present, the amount of heat liberated would evaporate the water in suspension. The scale on the inside of tubes may be easily removed by means of a tool formed with three spindles attached to a small turbine, the three spindles each carrying three or four chilled cutter wheels, the whole being fixed to a length of iron tubing which is connected to a pump by means of a hose. The only repairs likely to be necessary are the renewal of a few tubes, which can be readily obtained and fitted in a short time. Tubes, however, last a considerable time, and the only other repairs likely to be required are in the nature of a few fire bricks and fire tiles, although quite a different state of things exists with the Belleville, with its screwed-tube joints and nipple-pieces connecting the feed distributor to the headers, and the headers to the drum. All-water-tube boilers require regular and even firing, so as to prevent excess of cold air. Where there are two or more boilers, the feed supply does not require so much attention as would be the case if the furnaces were fired promiscuously and unevenly. Steam may be raised from cold water in about half-an-hour without setting up any permanent defects, and as regards coal consumption the published results of steam trials appear to show that the water-tube boiler can hold its own with the cylindrical type. **A. E. Mills,** *Proc. Inst. Marine Eng., Vol. XV.*, pp. 3-75.

Investigations in the Production of Superheated Steam.

THIS paper was undertaken with a view of shortly recording the results of a very extensive investigation into the production of superheated steam, a full exposition being forthcoming in the *Mittheilungen über Forschungsarbeiten.* As regards in the first place the properties of superheated steam, the specific volume, heating value, and thermal conductivity are especially important for its production. The specific volume is generally calculated from Zeuner's state equation for superheated vapour, having with the designations used in the case of the gas laws the following form :—

$$pv = RT - Cp^n \quad . \quad . \quad .$$

where constants R and C are for the tension p in kg./sq. cm. and the volume v in *cbm*

$$R = 0{\cdot}00509 \qquad C = 0{\cdot}193 \qquad n = \tfrac{1}{4}$$

As regards the heating value of superheated steam, the following equation is nearly universally adopted :

$$\lambda' = 606{\cdot}5 + 0{\cdot}305\, t_1 + 0{\cdot}48\,(t'_1 - t_1),$$

where the two former terms of the sum represent the liquid and vaporisation heats, the last one the superheat. The knowledge as to the thermal conductivity of superheated steam is limited to hypothesis and isolated experiences, some phenomena rendering the existence of a very small conductivity probable. In the second part of the paper, the advantages of cast-iron superheaters are discussed. From the considerations of the passage of heat through the superheating surface the following conclusion is drawn:—In superheaters using the whole of the flue gases in superheating the steam, the relation between the work performed by the boiler and the coefficient of the passage of heat will not show any material departure from a linear formula, both factors thus being approximately proportional. In the fourth part, the speeds of the steam in the superheater tubes are dealt with, the following factors having to be taken into consideration when choosing the convenient value of this speed : passage of heat, durability, and fall in tension. The speeds recorded vary between 4 and 28 mm per sec. With regard to the utilisation of heat in producing superheated steam as treated in the fifth part of this paper, the connection between the superheater and the boiler is of paramount importance. The determination of the efficiency in the case of superheaters with special fireplaces is difficult on account of the considerable influence exerted by a lack of knowledge as to the specific heat and the amount of water contained by the entering steam. It is shown that by fitting steam generating plants with such superheaters, the efficiency is lowered only by a little less than 5 per cent., provided both the boiler and superheater be well utilised. Building superheaters into the boiler will increase the efficiency of the latter, the original boiler being modified in two respects, as both the heating and radiating surfaces of the boiler are augmented by the superheating surface. The work done by the boiler in generating superheated steam is discussed in the last chapter, this factor being modified for two reasons when modifying the connection of the superheater with the boiler, viz., first, by the modification of the temperature fall controlling the passage of heat between smoke, gases, and water ; second, by the modification of the relative position of some heating surface elements of the boiler with regard to the fireplace, controlling to a high extent the efficiency of the boiler-heating surface. It is shown that compound hot steam locomobiles working with steam temperatures upwards of 300 degs. Cent., require simpler and cheaper steam-generating plant than wet steam-locomobiles of the same output. The use of superheated steam will therefore, in addition to the advantage of greater economy, be advisable also on account of the lower first cost of the steam generating plant —**O. Berner,** *Zeitsch. Ver. Deutsch. Ing., Vol. XLVII., Nos. 43-44,* pp. 1545-1552, and 1506-1594, 1903.—*A. G.*

Suction Gas Plant Tests.

GAS engines have entered a successful competition with steam engines on account especially of their being worked with so-called poor gases, the latter being produced either by a pressure generator or according to a more recent process by suction generators. In the latter case there is no steam boiler, the steam used in the production of the gas being formed by the heat of the exhaust gases and the radiant heat of the generator. From tests made on such a suction gas plant, the following conclusions were drawn :—In the generator there occurs a ready decomposition of water (0·991 kg. per 1 kg. Cent.) resulting in a low temperature of the generator, small amounts of slag and small radiation. On entering the scrubber the gases are relatively cool,

the scrubber water absorbing only 4 per cent. of the heat contained in the gas. The efficiency of the generator is very high, being 0·92 of the theoretical possible efficiency. As regards the motor, the nearly complete decomposition of water results in a gas rich in hydrogen, and accordingly of a high heating value, rapid and safe combustion of the heating gases, high explosive tension, and no dispersion in the diagram. On account of the high mean tension, the specific output of the motor is very high. Moreover, temperatures are relatively low on account of the high specific heat of water vapour; the efficiency is very satisfactory. The author thinks generator gas engines to be susceptible of further improvement.—**K. Bräuer,** *Zeitschr. Ver. Deutsch. Ing., Vol. XLVII., No. 24,* pp. 1517-1524.—*A. G.*

Streams of Gases and Vapours through Tubes with variable Section.

THE ever-increasing importance of steam turbines has drawn attention to the phenomena connected with the streams traversing these engines. As no reliable theory of these phenomena has so far been given, allowing in the first place for the influence of a widening of the outlet to be accounted for, the most contradictory conclusions have been drawn from former experiments. The author bases a theory on the well-known fundamental formulæ for the stationary streams of elastic liquids, without limiting the same by any dubious hypothesis, the solution being of a surprising simplicity. The theory developed in this paper shows, for example, all the phenomena observed by Stodola (*Z.D. Ing.*, p. 1., etc., 1903), to be in excellent accordance with other experiments, this being an evidence of the accuracy of the processes used by the various experimenters. The statement made by Zeuner, that the speed of the streams in widened tubes may grow beyond the velocity of sound, is confirmed for the case of the stream filling the tube completely. **H. Lorenz,** *Zeitschr. Ver. Deutsch. Ing., Vol. XLVII., No. 44., Oct.* 31, 1903, pp. 1600–1603. —*A. G*

Compression in the Gas Engine.

THERE is a difficulty in securing sufficient compression with danger of premature explosion. With blast-furnace gas there is but little hydrogen, and this gas is therefore safer to employ than Mond or similar hydrogenous gases. Some further information on the degree of compression to which gas engines are regularly and safely being worked would be useful to engineers generally. Unless pistons are water-jacketed, a gas engine cannot very well use a rich gas with a compression exceeding five atmospheres absolute. In the conventional gas-engine diagram, which has been laid down on steam-engine lines, the explosion is sudden and severe. An enormous temperature is generated in the cylinder at a time when the piston is standing still and the crank-shaft is revolving at full speed heavily pressed against its bearings, yet receiving no turning moment from the heavily-loaded piston. The heat of explosion is going rapidly into the jacket and heating water instead of doing useful work. Maximum pressure is attained when the crank is at a position of useful effort, and heat is applied to the expanding gases when they require it, and it is thus more efficiently converted into work than when set to heat the jacket water. As an engine, however, which to keep warm is our best endeavour, the steam engine is a superior machine to the gas engine, which has to be kept cold. The superior total efficiency of a gas engine over a steam plant is merely due to greater compactness of the whole cycle of operations.—**W. H. Booth,** *Elec. Rev., Vol. 53, No. 1,343,* p. 297.

Power and Economy of the Gas-engine as Influenced by the Fuel.

GOOD producer gas has about 55 per cent. of nitrogen and other inert ingredients, and as a result its heat value per cub. ft. of explosive mixture is about 80 per cent. of that for natural or illuminating gas. It is therefore possible to bring up the power of an engine to its natural gas standard by enlarging the cylinder diameter without making corresponding increases in shaft and other dimensions. Similarly with blast-furnace gas, which is more diluted even than producer gas, the cylinder diameters may be enlarged out of the natural gas proportion to the other dimensions of the engine. It is found that while the power of an engine varies somewhat with the fuel used, that thermal efficiency and hence the B.T.U. per b.h.p. is nearly constant. Twelve thousand effective B.T.U., whether from 12 cub. ft of natural gas, or from 85 cub. ft. of producer gas, will give 1 b.h.p. at full load in a suitably designed engine. From 10 to 12 cub. ft. of natural gas are required per b.h.p. hour. Illuminating gas is more troublesome than natural gas to use in a gas-engine, since the hydrogen it contains is rather touchy and sometimes ignites sooner than desired. Except for small engines and for the owners of gas-works, it is too expensive a fuel for power purposes. **W. P. Flint,** *Proc. Eng. Soc., West Pa., Vol. XIX., No. 4,* pp. 222-228.

Fuel Oil.

WITH a triple-expansion engine, one h.p.-hour may be obtained for 1½ lb. of coal per hour, and if the boilers, engine and condenser be properly looked after, this result is continuously possible. For many years refined oil has been used as fuel where the greater heat value alone determined the selection, but its use in large quantities in place of coal is confined to oil in its natural state. There are about 19,000 B.T.U. in 1 lb. of oil, and about 12,000 available units in 1 lb. of coal. In comparing the two fuels, it is not alone the difference in heat value per lb. that must be considered. There are objections to the use of coal which would make oil the more desirable fuel if the heat values were the same, provided the cost of oil allowed the selection. In the ordinary way of firing coal there is the opening and shutting of the fire-door, with the constant change of temperature to which most of the deterioration of boilers is due, and most of the expense of upkeep is entailed. Until the ashes from the burning of coal are removed from the

vicinity of a boiler, there is a constant deterioration of metal with which they are in contact. In burning oil, it is possible to dispense entirely with the temperature changes, there are no ashes to remove, and careful burning of the oil leaves very little unburned carbon. The burning of oil entails a minimum of expense for operating. The oil may be burned with the use of either steam or air, or both, to atomise it. In selecting an oil burner with a steam atomiser, care must be taken that the quantity of steam be not too great a percentage of the total amount generated. If the plant where oil is burned uses pneumatic tools, it may be more advantageous to use air. Where a forced-draught system of combustion is used, a combination of steam for atomising and air for combustion may be used. In a plant of over 4,000 h.p., using steam to atomise the oil and air at a pressure of 3 ins. of water for combustion, there is obtained regularly a net evaporation of 14·1 lbs. of water from and at 212 deg. per lb. of oil. The tubes are sponged in this plant once a month, as against every day when coal was used, and no repairs to furnaces or tubes have been necessary after seven months. **J. F. Rowland,** *Jnl. Franklin Inst., Vol. CLVI., No. 2,* pp. 139–141.

Steam Turbine-Driven Centrifugal Pumps for High Lifts.

During the recent drought in New South Wales, Prospect Reservoir became almost depleted, and a scheme had to be devised to supplement the supply by bringing water from the Nepean River, some 14 miles away, which necessitated a lift of 240 ft., including friction-head. It was clear that no ordinary form of reciprocating pumps would be equal to such a range of duty, and therefore it was decided to adopt centrifugal pumps in sets of three, and capable of being run in series or in parallel, the quantities and heights in each case adapting themselves to this system. Three firms were asked to tender, and the offer submitted by Messrs. Parsons & Co. was accepted. The first and largest set consists of a Parsons compound steam-turbine direct-coupled to three special high-lift centrifugal pumps. The steam-turbine shaft and the three pump-shafts are all independent, each being mounted on its own pair of bearings, and provided with claw-type flexible couplings. Each pump is designed to deliver 1½ million gallons of water per 24 hours against a head of 240 ft, when running at a speed of 3,300 revolutions per minute. The pump consists of a central double-sided runner, running in a closely-fitting bushed casing. The water, entering the pump at the bottom, is divided into two portions, which pass up the two sides and enter the runner through bell-mouthed passages. At each side of the runner there is a pair of small propellers, which assist the flow into the central runner. The shaft which carries the pump runner is 3¼ ins. in diameter, and is provided with special ring-and-groove glands, which serve, in the case of suction-pumps, to keep air out, and in the case of pressure pumps, to keep the water in. When used as suction-pumps the outer pocket of each gland is connected by a small pipe to a low-pressure water service, so that water may leak into the pump instead of air. The inlet pipe of each pump is 11 ins. in diameter, and the outlet from the volute is 10 ins. in diameter. The results guaranteed by the makers were as follows:—Quantity of water delivered per day of 24 hours in millions of gallons, 1·5; total lift or head in feet, 700; speed, revolutions per minute,

No. of Test.	1	2	3	4
Date	27 Jan., '03	3 Feb. 1903	—	—
Title of test	Contract	Contract	Overload	Superht.
Duration of test in hours	2	1·54	1·2	1·55
Steam-press. in lbs. per sq. in.	57	57	84	55
Vacuum in condenser, in ins. of mercury...	27·46	27·82	27·62	27·80
Barometer	29·65	29·89	29·89	29·89
Condition of steam	Dry & saturd.	Saturd.	Saturd.	95° F. Superht.
Weight of steam used per hr. in lbs. ...	7,039	7,208	9,398	6,667
Weight of steam per water h.p.-hr. in lbs.	27·93	30·67	28·83	27·89
Speed, revs. per min.	3,300	3,330	3,710	3,340
Mean delivery gauge readings in lbs. p. in. ... ... 1st pump	97	102	130	103
2nd pump	206	208	263	210
3rd pump	326	318	393	323
Height of suction in ft.	11	11	11	11
Total lift in ft.	762	744	917	756
Mills. of galls. water pump per day ... ... Venturi ...	1·573	1·499	1·689	1·503
Meter Orifice	1·623	1·513	1·723	1·555
Water h.p.	252	235	326	239
Gross h.p. obtainable from a perfect steam-engine on the Rankine cycle between given limits of temperature	720	759	1,049	733
$\frac{\text{Water h.p.}}{\text{Gross h.p.}} \times 100$	35·0	31·0	31·1	32·6

2,000 to 2,400; steam pressure, lbs. per square inch, 150; steam consumption per water h.p., 37. The results of tests conducted by Prof. Goodman are stated in the table on preceding page.—**C. W. Darley,** *Trans. Inst. C.E., Vol. CLIV., June, 1903.*

NAVAL ARCHITECTURE.

Experiments on the Resistance of a Screw Steamer in Free Route.

In order to ascertain as near as possible the exact proportion of the power developed in the engines to that utilised in overcoming ship resistances, some interesting experiments were recently carried out by Herr Murk Lels, director of the Kinderdyk shops, near Rotterdam. For the purpose, a small screw steamer of the following dimensions was used:—Length, 72 ft.; beam, 14 ft. 9 ins.; depth, 8 ft. 10 ins.; displacement, 70 tons; diameter of high-pressure cylinders, 12½ ins.; diameter of low-pressure cylinder, 25 ins.; stroke, 18 lbs.; boiler-pressure, 100 lbs. per sq. in.; diameter of propeller, 6 ft. 3 ins.; pitch, 7 ft. 7½ ins.; developed surface, 15 sq. ft. In order to measure the reaction of the pressure of the propeller on the water, two dynamometers of the Duckham type were attached to the thrust-block, which was made movable in a cast-iron sole-plate. Table I. shows the results of a series of runs. The results for efficiency show values excessively high. It would appear that the developed power may have been greater than as indicated in the diagrams. Nevertheless these results still have their values as a basis for comparison, since it may be confidently assumed with engines of about the same size that at least the relation between the power actually developed and that shown in the diagrams remains sensibly constant. With a view of investigating the accuracy of Froude's analysis and model research, two paraffin models were made of this form and subjected to the usual tests in the Dutch Government model tank at Amsterdam, under the direction of Herr A. von Beck. The results are given in Table II. Column 5 gives the net horse-power which, reckoning simply from model experiment, would be needed to propel the ship at corresponding speeds. Froude first called attention to the fact, which was later

TABLE I.

No. of Run.	Mean I.H.P.	Mean Revolutions.	Mean Load on Thrust Block in lbs.	Speed of Ship in Knots.	Speed of Propeller in Knots.	Slip per Cent.	Thrust Power.	Col. 8. / Col. 2.
1 up ... / 1 down...	31·03	94·0	1,907	6·97	7·08	1·55	19·76	63·68
2 up ... \ 2 down...	50·56	111·0	2,762	8·07	8·36	3·47	33·16	65·58
3 up ... \ 3 down...	80·24	127·5	3,966	9·02	9·6	6·04	53·22	66·32
4 up ... \ 4 down...	132·35	148·0	5,968	10·07	11·14	9·6	89·43	67·57
5 up ... / 5 down...	170·83	160·5	7,630	10·47	12·09	13·4	118·85	69·57
6 up ... / 6 down...	230·58	175·0	10,007	10·84	13·12	17·37	161·40	70·00
7 up ... \ 7 down...	260·32	180·5	11,007	11·01	13·6	19·04	180·29	69·25
1	2	3	4	5	6	7	8	9

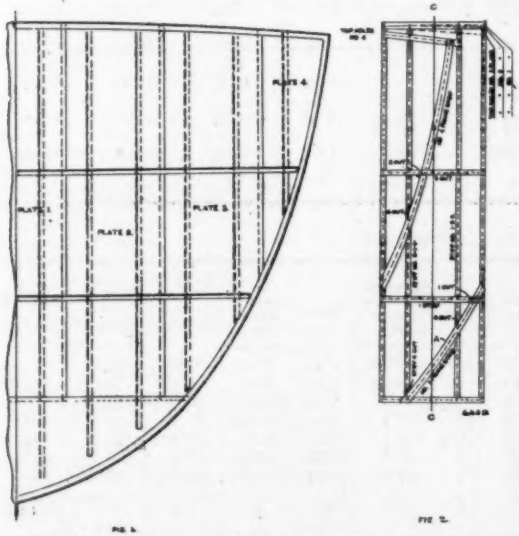
TABLE II.

No. of run	I.H.P. developed.	I.H.P. comptd.	Thrust Power.	Effective Power.	Revs.	Augmentation as per cent. of Col 5.	Slip.	Speed in Knots.	Col. 4. / Col. 2.	Col. 5. / Col. 2.	C. = $V^3 \times D^{\frac{2}{3}}$ / H.
1	31·03	26·38	19·76	15·80	94	25·06	1·55	6·97	63·68	50·9	183·3
2	50·56	45·24	33·16	27·42	111	20·09	3·47	8·07	65·58	54·2	174·5
3	80·24	74·36	53·22	42·74	127·5	24·5	6·04	9·02	66·32	53·3	153·6
4	132·35	128·67	89·43	70·69	148	26·5	9·6	10·07	67·57	53·4	129·6
5	170·83	176·37	118·85	87·75	160·5	35·4	13·4	10·47	69·57	51·4	112·8
6	230·58	246·44	161·40	108·46	175	48·8	17·37	10·84	70·0	47·0	92·8
7	260·32	278·91	180·29	120·22	180·5	49·9	19·04	11·01	69·25	46·2	81·1
1	2	3	4	5	6	7	8	9	10	11	12

proved by experiment, that at a given speed a ship propelled by its own propeller is subject to a greater resistance than if it were moved by a tow-line at the same speed. He termed this "augmented resistance," which is shown by the excess of the values of the thrust power (column 4) over those of effective power (column 5). In column 7 this excess is shown as a percentage of column 5. Froude announced as a result of his tests with the *Greyhound* that the propulsive co-efficient was found between 37 and 40 per cent., whereas Prof. Flaum notes that the values usually range between 46·2 per cent. and 54·2 per cent.—**H. Enno Van Gelder,** *Marine Engg., Vol. VIII., Nos. 8 and 9*, pp. 414–418 and 454–458.—*H. B. D.*

Practical Mould Work in Shipyards.

THE author indicates a method by which the cost of construction of ships could be reduced by resorting to a system of mould work in lieu of the almost universal method of templating. Too little attention is given in many yards to the manner of building the ship. Many foremen are incapable of judging the cheapest way of turning out the work from the drawing-office plans. Frequently they wait, before starting one portion of a ship, until all the preceding parts are in place, and then begin to template off clips, liners, plates, etc., of which a larger number could be laid off in duplicate at one-fourth the cost, besides having the parts ready when wanted. A man, who has qualified as loftsman and fitter, should be appointed to look after all moulds and loft work, in order that he may decide what work it may be profitable and advantageous to lay off from the loft and what may be templated. With moulds, fifteen plates would be a fair day's work, against three or four by templating, at a day's wage. As to piecework, the only difference will be a reduction in the price of plates and shapes laid off moulds, while the workman still earns the same wages with no increased manual labour. One great advantage would be that as the plating tends to fair the ship and holds the frames in position, the expense of ribbands and fairing the ship by carpenters would be dispensed with. Mould work enables the builders to proceed simultaneously with all parts of the hull. The reduced cost of riveting must also be noted; for many parts could be assembled on the ground and riveted by machines at a much lower cost per rivet, so as to leave but a small quantity of riveting to be done on the ship, with the exception of the shell and decks, which must be riveted in place. Even to-day there are firms who make a wooden mould for each frame for use on the bending slab, and then carry the frames and floors to the scrieve board and to and from the punch in order to transfer the holes from the frames to the floors and beam brackets, while by simply laying off and boring the moulds the expense of carrying hundreds of tons of steel to the scrieve board and the cost of the expensive scrieve board itself are dispensed with. The order of erecting a ship with framing and shell would be as follows: The keel plates would be laid on the blocks; the keel liners, the hull straps, keel bars, centre keelson plates, and stiffeners would be placed in position and well bolted together. Riveting and caulking should be commenced before floors are in place. The garboard strakes are then lapped on and followed by succeeding strakes of bottom plating to the lower turn of the bilge. The outboard strake should rest upon a ribband strong enough to carry the weight of the frames. The framing may then be commenced with, and the bottom plating should be bolted to the frames. Then proceed with the side-plating by starting at the deck and working downwards. It will not be found necessary to horn the frames, as the plating will bring them into their true position. The object in starting the plating at the deck is to keep the sheer fair. When inconvenient to erect frames with beams attached, they should be put in place as soon as the frames are erected. The inside work should follow the framing as closely as possible. All lap holes in frames and beams could be punched. Fig. 1 shows an example of bulkhead mould work; the moulds required would be as follows: One frame mould, one horizontal stiffener mould, one plate mould, one beam mould, one vertical stiffener mould. Fig. 2 shows the mould for the plates



MOULD WORK IN SHIPYARDS.

which serves for all the plates on the bulk-head. —**S. H. McLane,** *Marine Eng., Vol. VIII., No. 10,* pp. 526–528.—*H. B. D.*

Drilled v. Punched Rivet-holes in the Hulls of Ships.

When the Admiralty first stipulated that all the holes in destroyers were to be drilled, contractors thought this condition involved an increase of cost and time out of proportion to the better quality of work produced. The method we adopt is to drill the inside strakes of the shell-plating, etc., by electrically-driven radial drills placed near the boats in the yard. The plates are then sheared and put in position on the ship's side or bottom. The outer strakes of plates are drilled in place by portable pneumatic drills, the inner plates acting as jigs for the holes in the outer strakes. The electrical drills we use have arms like a double-jointed gas-bracket, so as to be very readily adjusted. The spindle has a quick return motion, so that as soon as it is relieved it rises clear of the work. These drills are each driven by an independent 1-h.p. motor, which is mounted at the centre on which the outer arm swings. The speed of the drills is variable between 250 and 500 revolutions per minute. We first used Morse twist-drills, but eventually made our own drills from "Speedicut" steel, and found that these were better suited to our purpose than any we had previously tried. By adopting the system described the holes are all dead true and equal in every respect to the best boiler-work. They are consequently ready for being riveted up without even a rimer or drift being used, nor any inaccuracy due to not getting the holes exactly in their correct positions. If this mode of construction were applied to our big liners their life would be prolonged; they would not so often need to go into dry dock to have loosened rivets replaced, seams recaulked, etc. In our class of work drilling holes does not adversely affect the cost or speed of construction; for although punching is more rapid than drilling, there are many more men employed. In drilling plates under a radial machine one man with suitable tools can perform the whole operation without any assistance, or any handling or moving of the plate. Punching must be done on one plate at a time, but it is often possible to drill several plates at once. We have ourselves used these machines repeatedly on batches of eight plates bolted together. The average time taken to drill a $\frac{3}{4}$-in. hole through eight $\frac{7}{16}$-in. plates is less than 40 secs. No punching machine, with its attendant gang, can rival this.—**A. F. Yarrow,** *Proc. Inst. C.E., Vol. CLIV., 1903.*

MARINE ENGINEERING.

The Bearings of Naval Engines.

The author deals with the method of adjusting the bearings of naval engines, and the proper treatment of one when damaged. In the first place he considers the Admiralty do not specify large enough bearings. A few suggestions based on actual experience may prove useful. First, as regards lubrication, the oil pipes must be kept clear, and the worsteds clean. Olive oil forms a good lubricant, but since the supply is limited on board, a good mixture can be made of 2 olive and 1 crane. The next point is the bearing itself. Bearings are usually adjusted in three different ways in the Navy. The first is by "swinging": that is, after the bearing has been adjusted, the rod is taken in hand and swung through an arc to test its tightness. The second method is by "flogging" up the nuts on the bolts till the brasses grip the journal, and slacking back again a given amount. Liners are then inserted. The third method is by inserting a piece or pieces of lead wire, tightening up to the former position, and then by removing the wires, and by its thickness gauging the amount of clearance between the journal and brasses. The most accurate and scientific method is by using lead wire and wire gauge. With regard to the wire gauge, we will take the legal standard gauge, as this is most generally adopted. For engines of battleships or large cruisers, 24 L.S.G. will be a good adjustment for all main bearings and crank-pin brasses, and 26 L.S.G. for the crosshead of white metal, or 24 L.S.G. if of brass. For engines of smaller cruisers, making from 120 to 180 revolutions per minute, 27 L.S.G. for main and crank-pin brasses, and 26 L.S.G. for crossheads, will be found satisfactory. But it is always better to err on the slack side, as it saves the use of sea-water, which not only spoils the journal but decays the white metal through setting up galvanic action. Engines of destroyers can be swung, but if leads are required a 30 L.S.G. for main bearings, cranks, and crossheads will run without trouble. Thrusts are almost universally of the horseshoe type, and can be easily set with feelers. First, the engines have to be got aft to the required position. If the valve-gear is true, the cranks and crossheads are not far out. Having got the engines central, the next thing is to tighten up the thrust collars and insert a thin feeler to prove that the collar and the shoe are parallel, and that the bearing is taking all over. Too much care to the exact measurement of all adjustments cannot be paid.—**"Naval Engineer,"** *Engineer, Vol. XCVI., No. 2494,* p. 370.—*H. B. D.*

Screw Propulsion for Naval and Maritime Purposes.

There are at present indications of the advisability of a return to the earlier designs of propeller having fan-shaped blades in place of the modern types, which usually possess blades quite narrow at the tips; and to further increase efficiency, blades should be given a curved, receding form, so as to reduce the resistance due to rotative action. Owing to increased rotative velocity of the screw, the surface which experiences rotative resistance should be modified to suit the new conditions. The power expended in driving a tail-race sternward is of a definite amount, but too large an area ratio will cause an excessive waste. Conversely, too small area will cause a slipping of the thread of water. Such action causes loss of propulsive efficiency. Rotation of water is inherent to the action of the screw; the loss owing to this could be lessened by giving a curved, receding form, so as to drive the water outwards towards the ends of the blades. An indispensable feature of both war and merchant ships is that they must be capable

of maintaining headway against heavy winds and seas. The writer is compelled to differ from many authorities with regard to the enormous increase of ship resistance after economical speed has been reached. May not a larger part of the excess i.h.p. be due to the increased waste of power incident to the screw propellers at a high rotation? This is a question that can only be settled by direct experiment on a full-sized ship, with engines and propellers working at the highest speed. The recent trials of *H.M.Ss. Drake*, *King Alfred*, *Good Hope*, and *Leviathan* have afforded, so far as their results have been published, an opportunity for investigating—(1) the resistance of ships at various speeds; (2) the expenditure of engine power at various speeds; (3) the irreducible, non-productive expenditure of power; (4) the reducible non-productive expenditure of power. The following formulæ will merit close examination by those who are interested in the increasing size, speed, and economy of our ships of war and commerce. Basing calculations on towing resistance of *H.M.S. Greyhound*, we have:— L_1 = length = 172 ft.; C_1 = coefficient of fineness = ·575; S_1 = speed before resistance increased more than S^2, = 8 knots. For cruisers of the *Drake* class:— L_2 = 500 ft.; C_2 = ·525; S_2 = speed to be ascertained before resistance increases more than S_2^2.

Then $S_2 = \frac{L_2^{\cdot 683} \times C_2 \times S_1}{L_1^{\cdot 683} \times C_2} = \frac{500^{\cdot 683} \times \cdot 575 \times 8}{172^{\cdot 683} \times \cdot 525} =$ 21 0 knots. The analysis of the *Drake's* trials shows a similar result. From the *Greyhound* experiments it appears that resistance varied as S_2 up to 8 knots, and at 10 knots $R_1 \propto S^{2\cdot 83}$—required speed of *Drake* before $R \propto S_2^{2\cdot 825}$. Using same values, except that S_1 = 10 knots, we have $S_2 = \frac{500^{\cdot 683} \times \cdot 575 \times 10}{172^{\cdot 683} \times \cdot 525} = 27$ knots. Thus at 27 knots the *Drake* will vary as $S^{2\cdot 825}$, and net h.p. for propulsion should only vary as $S^{3\cdot 825}$. But between 20·03 knots and 22·16 knots the i.h.p. varies as $S^{4\cdot 16}$. With the original blades of 152 sq.ft. total helicoidal area, it appears that between 22 and 23 knots in the *Drake* the gross i.h.p. varied as $S^{6\cdot 736}$, in the *Leviathan* as $S^{5\cdot 696}$, the *Good Hope* as $S^{7\cdot 716}$, and *King Alfred* as $S^{3\cdot 8}$, and in the *Kent* as $S^{7\cdot 3}$. This discrepancy disproves the theory of the increase of gross i.h.p. being entirely dependent on hull resistance at the higher speeds. We shall certainly find it is the propellers which fail in efficiency at the higher speeds and not, as is popularly supposed, the ship resistance, and that thus the larger part of the gross i.h.p. is spent uselessly. The writer is aware that the above results do not accord with those deduced from tank experiments, but until actual towing experiments with large ships in deep water have proved that the resistance of long fine ships increases suddenly as the fourth to the tenth power of the speed, he cannot but regard the above results as being nearer the truth than those obtained from models. The proportion of helicoidal area to i.h.p. to secure maximum efficiency at the highest possible speeds is worthy of the most serious attention. In the case of *H.M.S. Drake* the greatest efficiency was attained between 15 and 20 knots, where there were only 30 to 70 i.h.p. per square foot of helicoidal area. As the proportion rose from 150 to 200 i.h.p. per square foot of helicoidal area, the efficiency fell off. Decline in efficiency is ascribed entirely to the enormous increase of wave-making resistance; the writer maintains, however, that it is due to insufficient helicoidal area of blades generally, and to insufficient width of blades, and to the force of blade surface being unsuitable to the high speed of the propellers. The writer agrees generally with the commonly accepted percentage of loss due to internal friction of the engine. Propellers having the smallest or largest amount of slip do not always give the best results. The propeller is best which gives the largest value at all speeds to C_s and C_D where $C_s = \frac{S^3 \times I.M.S.}{I.H.P.}$ and $C^D = \frac{S^3 \times D^{\cdot 666}}{I.H.P.}$. There is a certain proportion of power which must be expended on the water, whatever the wake or eddy motion may be. If propellers be designed with a liberal proportion of helicoidal area to i.h.p., say 1 sq. ft. to 70 i.h.p., it is a simple matter to reduce that surface in the event of finding the pitch and area of blades being too great for the engines. The writer believes that very great improvement would be made in the average passages of all our high-speed steamships if the helicoidal areas of all propellers were increased by 30 or 40 per cent. by the substitution of four-bladed screws for three-bladed ones.—**G. Quick,** *Fleet Engineer (Retired) H.B.M. Navy, Trans. Am. Soc. Nav. E., Vol. XV.*, pp. 637-659. —*H.B.D.*

Cavitation with Screw Ships.

THE attention of marine engineers has recently been directed to a phenomenon which may become manifest in the operation of a screw propeller, especially at high speeds. The water rushes towards the propeller in virtue of the pressure of the atmosphere, augmented by that due to the height of the water-line above the point of the propeller under consideration. The cylinder of water remains entire so long as its velocity does not exceed a certain value. Beyond such value cavities are formed in eddies and whirls. The quantity of momentum impressed on the water by the propeller measures the ship's resistance. If the velocity is so high that cavitation is produced the natural remedy will be to augment the mass of liquid acted upon, which in turn is proportional to the surface of the propeller. These considerations have led me into a simple rule: The propulsive surface should be proportional to the product of the resistant surface by the speed—or, more exactly, to the quotient of the power by the square of the speed. This gives the following equation: $n d^2 r^1 = J \frac{F}{V^2}$ n = number of propellers, supposed to be identical; d = diameter of propeller in feet; r = ratio of developed surface of one propeller to that of the circumscribed circle; F = maximum i.h.p.; V = speed of ship; J = numerical coefficient. Experience shows that J,

which should be greater as the fineness of form relatively to the speed is less, should never be less than 6·5, and may with advantage even exceed 8·5. The author proceeds to quote an example of a warship of 14,300 tons displacement and 30,000 i.h.p., which with the original propellers showed a remarkable decrease of efficiency at the highest speed; indeed one knot extra at that speed would require 15,000 or 20,000 additional i.h.p. New propellers were tried having considerably greater propulsive surface, resulting in an increase in speed of one knot for the same i h.p. Evidently cavitation was produced with the original propellers. By the above formula f showed a value of 4·5 in the first instance, whilst in the latter it was 6·5.—**J. A. Normand,** *Marine Engg., Vol. VIII., No. 8,* pp. 411, 412.—*H. B. D.*

(In a letter to the *Engineer*, Oct. 16th, 1903, the author of the above paper states that the warship mentioned is H.M.S. *Drake*, and says that although by increasing the propulsive area of the propellers and consequently raising the value of the coefficient f, resulting in one knot increase of speed, he still considers that the propellers are not yet large enough.)

A Problem connected with the Screw Propeller.

THE writer discusses a method for dealing with the problem of the screw propeller, which generally is: given power and speed, the propeller is required. In connection with the various questions relating to screw propulsion, however, the inverse problem may arise: given ship and propeller and the turning moment on the shaft, what will be the revolutions and speed? To appreciate the problem properly it will be well to call attention to the two following propositions:—(1) The work developed by the engine is measured by the product of the turning moment, by the angular velocity, or by 2π-times the revolutions. (2) The schedule of steam pressures through the engine fixes its turning moment. It will be noted in particular that the power is not known and cannot be considered as a known quantity, since it depends upon revolutions—one of the unknown conditions to be determined. The problems may arise in many forms, but all involve similar fundamental conditions, and in none can the power be considered as one of the known quantities. It will be seen that none of the formulæ commonly adopted will deal with the problem here proposed; thus it will be necessary to use such equations as are available and transform them as may be suited for the solution of the problem. We shall use the following notation:—W = I.H.P.; Wp = power delivered to propeller shaft; f = mechanical efficiency of engines; U = net work developed by propeller; e = efficiency of propeller; A = area of low-pressure piston; pm = mean effective pressure reduced to low-pressure cylinder; Q = turning moment on shaft; T = thrust; R = resistance; d = diameter of propeller; p = pitch of propeller; N = revolutions; u = speed in knots; k = factor in propeller equation denoting influence of slip; l = factor denoting influence of pitch ratio; im = combined factor denoting influence, shape, and area of blades; $h = k \div (1 - s)$. Then, in general, we have—

$$Q = f_1 (d\ p\ N\ u\ im) \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

$$T = f_2 (d\ p\ N\ u\ im) \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

$$R = f_3 \text{ (ship, speed)} = T \quad \ldots \quad \ldots \quad (3)$$

By supposing forms of equations (1) and (2) known, we can suppose N to be eliminated between them. We may express this in the form

$$T = F (Q\ d\ p\ u\ im) \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

The propeller and ship are assumed to be fixed, hence N and u remain unknown and variable. We may re-write the equations as follows:

$$Q = f_1 (N\ u) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

$$T = f_2 (N\ u) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

$$R = f_3 (u) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

and by eliminating (5) and (6) $T = F (Qu)$ (8)

Now $T = R$, and from (7) and (8) determine u. This will serve to determine N, and any other feature desired.

None of the ordinary formulæ relating to propeller design or its performance are in the form as called for by (1), (2), (4), (5), or (6). These may, however, be developed by suitable procedure. The fundamental equation for the propeller may be expressed as follows:

$$U = d^2 (p N)^3\ k\ l\ im \quad \ldots \quad \ldots \quad \ldots \quad (9)$$

(For derivation see author's text-book on "Resistance and Propulsion of Ships," Chapter IV.)

$$u = pN (1 - s) \div 101{\cdot}3.$$

$$T = U \div 101{\cdot}3u = U \div pN (1 - s) \quad \ldots \quad (10)$$

Then, if we put $k \div (1 - s) = h$, we shall have from (9) and (10)

$$T = d^2 p^2 N^2\ h\ l\ im \quad \ldots \quad \ldots \quad \ldots \quad (11)$$

and by derivation

$$Q = \frac{Wp}{2\pi N} = \frac{d^2 p^2 N^2\ k\ l\ im}{2\pi e} \quad \ldots \quad \ldots \quad (12)$$

$$\text{also } Q = \frac{f\,pm\,LA}{2240\pi} \text{ ton-ft.} \quad \ldots \quad \ldots \quad \ldots \quad (14)$$

In equations (11) and (12) the only unknowns and variables in the case of a given propeller are N, k and h, writing these equations as follows:

$$\frac{T}{a^2 p^2\ l\ im} = N^2 h \quad \ldots \quad \ldots \quad \ldots \quad (15)$$

$$\frac{2\pi\ Q_e}{d^5 p^3\ l\ im} = N^2 k \quad \ldots \quad \ldots \quad \ldots \quad (16)$$

The expressions on the left may be called respectively the thrust and torque constants. Let these be denoted by T_1 and Q respectively; then we have

$$T_1 = N^2 h \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (17)$$

$$Q_1 = N^2 k \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (18)$$

$$\text{whence } \frac{Q_1}{T_1} = \frac{k}{h} = (1 - s) \quad \ldots \quad \ldots \quad (19)$$

$$\text{and } S = 1 - \frac{Q_1}{T_1} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (20)$$

$$\text{Again, } u = pN (1 - s) \div 101{\cdot}3 \quad \ldots \quad \ldots \quad (21)$$

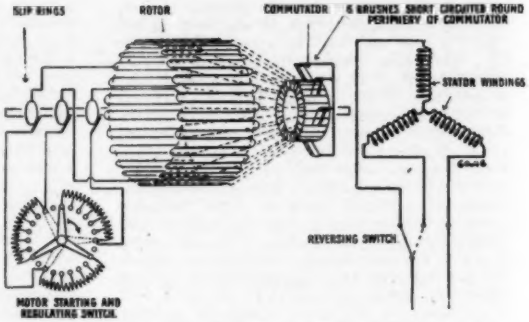
$$\text{and } \frac{101{\cdot}3u}{p} = N (1 - s) \quad \ldots \quad \ldots \quad \ldots \quad (22)$$

The ratio $101{\cdot}3u \div p$ may be called the speed constant, and represents the ratio of speed to pitch; this we shall denote by x_1. Then $x_1 = N (1 - s)$. —**F. W. Durand,** *Trans. Am. Soc. Nav. E., Vol. XV., No. 3,* pp. 887–901.—*H. B. D.*—*(To be continued.)*

APPLIED ELECTRICITY.

Steam-Turbine Electric Generating Plants.

A BRIEF account is given of the leading characteristics of the chief types of turbo-generators now manufactured, namely: the De Laval, a radial-flow turbine driving the generator through reducing gear; the Parsons, a parallel-flow machine driving direct; the Westinghouse, the Willans & Robinson, and the Brush modifications of the Parsons principle; and the Curtis, which has a vertical driving-shaft carrying the field magnets (surrounded by a stationary armature) at its upper end. The author condemns the more usual practice of revolving the generator armature, as this is less fitted to endure the high speeds usually attained. The economy of space and buildings, and also of steam consumption effected by generators driven from turbines instead of from reciprocating engines, is shown by the following figures. The Sulzer-Kolben 3,500-kilowatt two-phase generators and reciprocating engines installed at the Willesden works of the Metropolitan Electric Supply Co. weigh, with condensers, about 585 tons, and the space occupied by the foundations is 60 ft. 2 ins. by 21 ft. 6 ins., while the vertical height from floor to top of the piston tail-rods is 33 ft. 4 ins. A Parsons turbo-generator of similar output weighs about 148 tons, and the space required is only 37 ft. 1 in. by 8 ft. by 14 ft. 6 ins. in height, plus an equal depth beneath for the condenser room. A Curtis set of 5,000-kilowatt output weighs about 175 tons, and does not occupy a space exceeding 20 ft. by 15 ft. by 30 ft. high. In this size the condenser forms the base of the set. The maximum guaranteed steam consumption for the Sulzer-Kolben engines, with saturated steam at 150 lbs. pressure and a 24-in. vacuum, works out at 22·2 lbs. per kilowatt-hour at full load and 23 lbs. per kilowatt-hour at half load. The guaranteed steam consumption of the Parsons turbo-generator, with 150 lbs. pressure, 28 ins. vacuum, and 100 degs. Fahr. superheat, is 17·5 lbs. per kilowatt-hour at full load and 20 lbs. per kilowatt-hour at half load. Exact figures for the 5,000-kilowatt Curtis plant installed at Chicago are not yet available, but it is also much more economical than the Sulzer-Kolben. Further data are given to show the superior efficiency of turbine plants at low loads, and that they maintain their economy of steam consumption after several years' working.—**Geo. Wilkinson,** *Paper read before the Leeds section of I.E.E., Oct. 22, 1903.—E. J. W.*



CONNECTIONS OF THE SCHÜLER-FERRANTI SINGLE-PHASE MOTOR.

Starting switch shown, with resistance entering on first stop. The dotted lines show position of starting switch with resistance short-circuited.

A New Single-phase Motor.

THE Schüler-Ferranti motor aims at meeting the need for a machine which will give a big torque when starting under load without absorbing an excessive current. To this end it combines the properties of a repulsion and an induction motor. The following diagram shows the scheme of connections. The rotor is designed like an ordinary continuous-current armature but with three slip-rings connected to the windings at the end opposite to the commutator. The latter has six brushes permanently short-circuited. By means of the slip-rings resistance is put in series with the rotor-circuit at starting, thus causing part of the current to be shunted through the commutator brushes; and by varying the resistance a range of speeds from half to full can be obtained. The stator winding resembles that of a polyphase induction motor — in the figure a three-phase winding is shown. Only two sections of this are in circuit together, and by changing one over to the remaining section, reversal is effected. Tests of a 5 b.h.p machine showed a starting torque three times the normal with a current not exceeding twice the normal, while the normal working current gave a starting torque 25 per cent. above the normal running torque. When starting unloaded the motor only took one-quarter of its full-load current.—*Elec. Times, Vol. XXIV., No. 626,* pp. 551-552.—*E. J. W.*

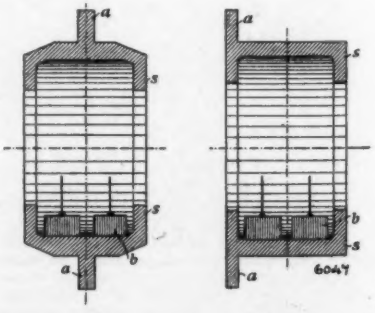


FIG. 1. FIG. 2.

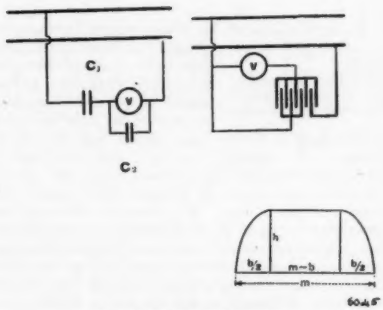
COMMUTATOR BRUSHES.

Commutator Brushes running in Oil.

THE author maintains that great advantage would result from running commutator brushes under oil, not merely because general experience indicates that friction losses and wear and tear due to parts revolving in contact with one another can only be reduced to a minimum by plentiful lubrication, but also because the oil would practically extinguish the sparking, as it does when employed in high potential switches, thus necessitating fewer sections in the commutator for any given voltage, and less cross-sectional area to the brushes for any given current. Figs. 1 and 2 illustrate how this proposal may be carried out in practice in a simple manner, which avoids the difficulties attendant upon any attempt to surround an ordinary commutator with an oil-chamber. Instead, the commutator itself serves to contain the oil, being made hollow with inwardly-projecting flanges *s*, and the brushes *b* rub on its interior surface, round the whole of which the oil will be carried by centrifugal force; but in the case of a series-wound armature only requiring two brushes, they can both be arranged to come near the bottom and actually dip in the lubricant. The only difference between the two designs is in the position of the exterior lugs *a*, to which the armature wires are connected. In neither case is the method shown of fixing the commutator on to the shaft, but it should present no serious difficulty.—**M. Osnos,** *Zeitsch. Elektrotechnik, Vol. XXI., No. 41,* pp. 580-582.—*E. J. W.*

Capacities as Multipliers for Electrostatic Alternating Current Voltmeters.

In the direct measurement of high p.d. with electrostatic voltmeters there is always a liability to sparking between the plates. To measure high p.d. with low-reading instruments, either a transformer has to be used, or else non-inductive resistances connected in series with the voltmeter, shunted or unshunted; but the first method is unpractical by reason of the power it wastes, while the latter involves apparatus cumbersome and troublesome to insulate properly. The authors propose to overcome these difficulties by coupling two capacities in series, and shunting an electrostatic voltmeter of relatively small capacity across one of them, as shown in Fig. 1. If C_1 and C_2 be the values of the capacities in farads, V_2, the p.d. at the terminals of the one in parallel with the voltmeter, and E the total p.d. across both capacities; then $\frac{V_2}{E} = \frac{C_1}{C_1 + C_2}$ provided, the insulation resistances of the capacities are equal and very large. Between the reading of the voltmeter and the p.d. under measurement, there is therefore a constant ratio which may be of any desired value by suitably proportioning C_1 and C_2. Advantages of compactness and saving of material are gained by making up the two capacities into one condenser, as shown diagramatically in Fig. 2. In either case, alternate sheets of tin or copper foil and mica are clamped between strong ebonite plates, and the whole immersed in a vessel containing oil. Tests of two instruments



ELECTROSTATIC VOLTMETER.

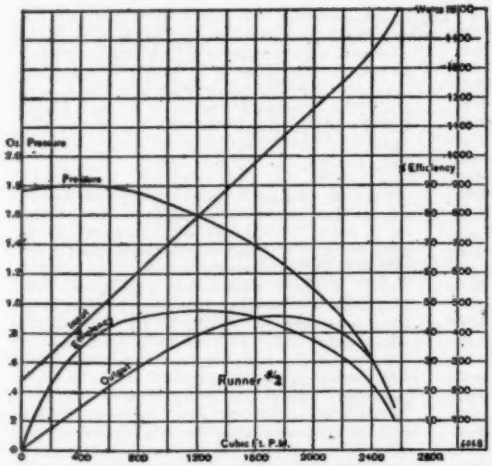
on this principle, one with a ratio of about 1 : 2 between the measured and actual p.d., and the other with a 1 : 40 ratio for p.d. up to 10,000 volts, showed in every case a difference of less than 1 per cent from the mean value of the ratio, and mostly the agreement was much closer.—**Prof. E. W. Marchant** and **G. W. Worrall,** *Paper read before the Bh. Assn., Report Electrician, Vol. LI., No. 25,* pp. 1000-1.—*E. J. W.*

Cost of Electric Power in Factories.

FACTORY managers and engineers are apt to assume that they can run their works just as cheaply with their own steam plant as it can be supplied them electrically from a central station, but investigation frequently shows that they have omitted from consideration many items which go to make up the actual plant costs. In addition to salaries, supplies, coal and water, there are repairs, depreciation, interest on capital, insurance, taxes and other costs, all of which have probably been merged in the general accounts. But besides comparing costs per kilowatt-hour the actual consumption will also be less with electric power, as all waste due to constant unnecessary running of generating machinery, pumps, shafting, pulleys, belts, etc., will be eliminated. Detailed figures are given of a factory whose total plant costs per month were about £190, but by the installation of motors totalling 400 h.p. and supplied with electric power at 2*d.* per kilowatt-hour, the figure was reduced to £160 per month. It does not pay to install cheap motors to keep down the first cost, if the saving is effected at the expense of their efficiency, for a very slight inferiority in this respect will render them far more expensive in the long run. For example, if two motors, costing respectively £50 and £45, but the latter 3 per cent. less efficient, averaged 6 h.p. per day of 10 hours for a year of 312 days, the cheaper motor would consume extra power equivalent to over £4 at 2·5*d.* per kilowatt-hour, and this sum capitalised on a 5 per cent. basis would raise its cost to about £66 as compared with the £50 machine.—**E. W. Lloyd,** *Paper read before Assn. Edison Illuminating Companies, Report Elec. Wld., Vol. XLII., No. 13,* pp. 512-4.—*E. J. W.*

Electric Motors for Centrifugal Pumps and Fans.

A KNOWLEDGE of the power required to operate a centrifugal pump or fan at a rated speed and head is far from sufficient to determine what size motor should be provided, because the maximum load that can come upon it if the head varies may be far in excess of the rating. Owing to the rapid fall of efficiency at heads below the rating, the power absorbed may be much greater, even though the energy output is less. In a case—by no means an extreme one—such as is illustrated by the accompanying curves of the performance of a centrifugal pump running at constant speed, a motor, fully loaded, when driving a pump rated at the point of maximum efficiency, would receive an 89 per cent.



CURVES SHOWING OPERATION OF CENTRIFUGAL PUMP.

overload if the pump had to work at the lowest head shown. The power consumption of centrifugal apparatus alters more rapidly with change of speed than probably any other class of machinery, and this is why a steady pump load is so effective in preventing the racing of generators, and in maintaining a constant voltage. If the head varies as the square of the speed, which often happens with ventilating fans, then the load is proportional to the cube of the speed, and the C^2R losses in the armature to its sixth power; while, if the head is constant, as in pumping against a fixed lift, the ratio of change of load with speed is still greater. This consideration points to the installation of motors of ample size for such work, and to caution in the use of resistance for weakening their magnetic field when increased speeds are wanted.—**A. J. Bowie, Jr.,** *Paper read before Am. I. E. E., Sept. 25, 1903; Report Elec. Rev. N.Y., Vol. XIII., No. 15,* pp. 511–3.—*E. J. W.*

Speed Regulation of Polyphase Motors.

THE different methods of varying the speed of two- or three-phase motors may be classed under four main headings: (1) Varying by means of a reactance or "compensator" the potential applied to the stator. The rotor—preferably of the squirrel-cage type—must contain a large resistance in circuit. The most favourable conditions for this method are intermittent loads, and speeds not less than one-half the nominal, and under these circumstances it is the cheapest; but the motor takes excessive currents at starting and is very inefficient at low speeds. (2) Inserting resistance in current with the rotor winding, which must therefore be connected to slip-rings and brushes. This is the simplest means of control, giving a range from standstill to full-speed; but is not efficient, although slightly more so than the preceding one. It is most suitable for frequent starting and low speeds, as it makes no abnormal demands on the supply system, (3) Altering the coupling of the stator windings so as to change the number of poles. This only gives as many speeds as combinations, but at these the efficiency is very good. For a wider speed-range the method must be combined with one of the others. (4) Varying the frequency. To do this requires complicated devices or auxiliary apparatus and wires in proportion to the number of speeds desired; but, given these, the efficiency is excellent.—**W. L. Slichter,** *Paper read before the Am. Soc. Mech. Eng., Report Electrician, Vol. LI., No. 26,* pp. 1044–5.—*E. J. W.*

Iron Losses in Dynamos.

THE iron losses in continuous-current dynamos in comparison with those of transformers are as 2·5 : 1, and a difference in the ratio of 1·9 : 1 can be explained by taking into account the effect that the slope of the flux distribution wave in either case has upon the eddy losses, leaving only ·6 to be accounted for by rotating hysteresis and other causes. The so-called full-load increment in iron loss can in a measure be ascribed to the skewing of flux due to cross-magnetisation, and this cause may increase the eddy loss to almost any value. The ideal flux distribution curve for a minimum iron loss is a parabola degenerating into a flat top with parabolic sides, the formula being $b = \frac{m}{4k}[(25k + 9)^{\frac{1}{2}} - 3]$, where b is as shown in the figure, m is the pole-pitch, and k is the ratio of the co-efficients of hysteresis and eddy loss for a parabola with height $h = 1$, and base m. For a given pole-pitch there should be less and less flat top the greater the periodicity, *i.e.*, the revolutions. In the case of alternators of low frequency a flat top wave should be aimed at when the hysteresis is more important than the eddy loss, but when the former is practically negligeable

compared with the latter, the condition $b = 75\,m$ should be fulfilled.—**A. Press,** *Electrician, Vol. LI., No. 26,* pp. 1049-1050.—*E. J. W.*

A New Process for determining the Dielectric Strength of Highly Insulating Substances.

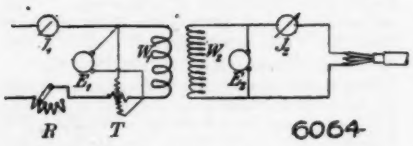
THIS process is based on the discovery made by the author in conjunction with Prof. Kiessling, viz., that even rather thick layers of highly insulating substances may easily be perforated by electric means, when there is poured on one of the surfaces a drop of hot wax, stearine or the like, about 2 cm. in diam. and 2 mm. in height and perforating the latter, after it has become quite cold, by means of a thin needle as far as the plate to be pierced. Now the author observed the fact that for a given plate of a similar substance there is always a certain minimum spark length for which the perforation is just possible, this minimum spark length being proportional to the thickness of the plate for the same substance. Dr. Walter therefore terms dielectric strength of an insulating material the minimum spark length in air, producing a perforation in less than a minute in layers of the material 1 cm. in thickness. The following table contains some figures recorded by the author:—

1	Pure hard rubber	20 to 77
2	Hard rubber coloured with cinnabar	12
3	Hard rubber coloured with zinc oxide	10
4	Common glass	16 to 18
5	Lead glass	11
6	White alabaster glass	23
7	Black alabaster glass	17
8	Common plate porcelain ...	15 to 19
9	Hermsdorf hard porcelain ...	18 to 21
10	Marble	13
11	Galalite	12 to 17
12	Stebelite	19 to 35
13	Homogeneous mica	35 to 57
14	Colophony	22
15	Wax	23
16	Paraffin	23
17	Soft rubber	37

Dr. A. Walter, *Elektrotechnische Zeitschrift, No. 39, 1903,* pp. 796–802.—*A. G.*

Energy Losses in High-tension Cables.

ONLY a few experiments on real high-tension cables have so far been performed in Germany; on the other hand, experiments on the energy losses in such cables, as published in England and America, especially by Mordey, do not appear to be very reliable. The experiments recorded in this paper were made on a number of high-tension cables constructed by the Allgemeine Elektricitäts-Gesellschaft, all the specimens being of the treble type, rubber, impregnated jute fibres, paper or combinations of several of these substances being used as insulating material. The method used was as follows:—In the circuit of an alternating-current machine of 50 periods per sec. there was inserted a hot wire amperemeter J_1, the low-tension coil W_1 of the



ENERGY LOSSES IN HIGH-TENSION CABLES.

transformer used, as well as the main current coil of a Siemens & Halske torsion wattmeter T, the tension coil of which, as well as the hot wire voltmeter E_1, were connected in parallel to the terminals of the transformer, and finally a controlling resistance R. In parallel to the secondary coil W_2 of the transformer, there was connected the static voltmeter E_2; the current traversing the cable was measured by means of the hot wire amperemeter J_2. From the results recorded in this paper it is inferred that the quadratic law for the dependence of the energy loss in dielectrics on the pressure is true even for cables, up to all the tensions investigated, provided the insulation be such that the limit of dielectric strength is not yet reached. This result is particularly important in view of the statement frequently made that the dielectric losses in cables should be directly proportional to the pressure. It is next inferred from these experiments (which are being continued) that using a suitable impregnating matter will allow of the losses being maintained at very low values. — **Dr. Richard Apt** and **Carl Mauritius,** *Elektrotechnische Zeitschrift, No. 43,* 1903, pp. 879–885.—*A. G.*

Mild Steels as employed in the Construction of Electric Machines.

THE author has investigated the mild steels as used in the construction of electric-machines, the first point considered being their electric resistivity. The results obtained by C. Benedicks, viz., that a dissolved atom of a body, expressed by its "value in carbon," will augment the resistivity by constant quantities, viz., 5·9 microhm cm., are borne out by Barrett, Brown, and Hadfield's experiments. As regards the permeability, the highest value found by the author in the course of measurements made by means of a Picou permeameter on square bars of silicon and aluminium steels, containing 2·5 per cent. of either of these metals is 2,260, corresponding with an induction of 6,000 C.G.S. In order to confirm indirectly a hypothesis according to which hammering the steel would result in breaking and deforming the constituent grains, thus augmenting the hysteresis, the author has adopted an artificial system by which the structure of hammered steel is roughly represented by soldering together a bundle of mild iron wires, 2 mm. in diameter, and cutting more or less inclined sections out of this bundle. The author thinks the conditions to be obtained are a high purity and great accuracy and regularity in softening, the only point to be improved being the regularity. Mr. Charpy thinks, however, the silicon and aluminium steels

present great possibilities of further improvement on account of their great permeability and low hysteresis. **G. Charpy,** *Écl. Élec., Vol. XXXVII., No. 44, 1903,* pp. 169–180.—*A. G.*

Influence of Number of Revolutions on the Design of Direct-Current Machines.

THE considerations given in this paper are based on the following facts: (1) The cost of material and work is a minimum in the case of the ratio of the length of the armature to the diameter of the latter being great, even if this involves greater expense in effective material. (2) The smaller the number of revolutions, the more advantageous will be a high value of this ratio. (3) The lesser ventilating effect of the armature in the case of small values of the numbers of revolutions may be compensated by augmenting the number of ventilating slots; this number may in rough approximation be increased inversely as the centrifugal force at the periphery of the armature. The main results of the paper are as follows: (1) Direct-current machines are best adapted for low values of the numbers of revolutions; with each given output there will correspond a number of turns for which the price of the machine is a minimum. (2) Direct-current machines of equal outputs but different numbers of revolutions should have the same diameter of the armature. (3) The first cost of a machine is proportional to $D\,L$, where D is the diameter of the armature, L the length of the armature as measured between the terminals of the coil.—**H. M. Hobart,** *Elektrotechnische Zeitschrift, No. 40, Oct. 1, 1903,* pp. 821–825.—*A. G.*

LIGHTING, HEATING, and VENTILATION.

Mean Candle-power.

THE bulbs of glow lamps act like concave mirrors producing bands of light in particular directions, as shown by Figs. 1 and 2. Dark bands are produced when a vertical portion of the filament is parallel to another portion of it. These effects produce rapid azimuthal variations

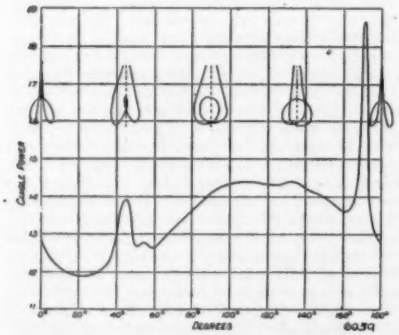


FIG. 1.—MEAN HORIZONTAL CANDLE-POWER CURVE ROUND A CLEAR BULB 16-CANDLE-POWER GLOW LAMP.

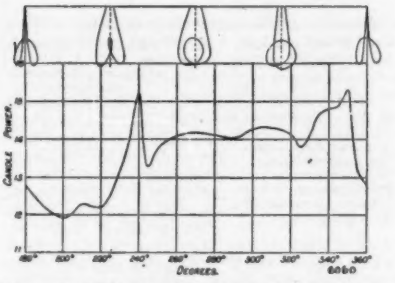


FIG. 2.—MEAN HORIZONTAL CANDLE-POWER ON THE OTHER SIDE OF THE SAME LAMP.

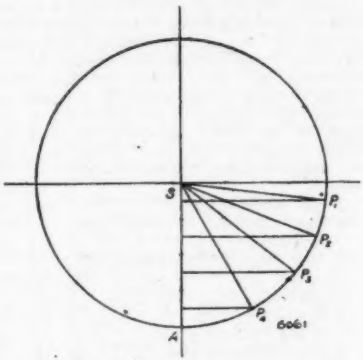


FIG. 3.—CONSTRUCTION FOR FINDING THE DIRECTIONS IN WHICH TO MEASURE THE CANDLE-POWERS, WHOSE MEAN VALUE WILL GIVE US THE MEAN SPHERICAL CANDLE-POWER.

$S\,A$, the lower radius of a circle, is divided into any number of equal parts, and through the middle points of these equal parts lines are drawn perpendicular to $S\,A$. $S\,P_1$ and $S\,P_2$ are the required directions.

of the light. In determining the mean horizontal c. p. of glow lamps, when no diffusers are used, a large number of observations must be made. This number may be reduced by using suitable diffusers. When glow lamps are used as standards it is of vital importance to study the horizontal c. p. curve before choosing and marking the direction in which they are to face the photometer screen. Neglect of this precaution even with ∩-filament lamps leads to large errors. As a rule the plane of the filament is perpendicular to the axis of the bench. The mean horizontal c. p. curves got by comparing a lamp with two standards of different powers may show distinct variations due to the relative mirror effects of the bulb being different at varying distances of the photometer screen from the lamp. Several simple formulæ and graphical constructions are given for determining the mean spherical and the mean hemispherical c. p. of sources of light. The simpler

practical method of determining the mean lower hemispherical c. p. of an arc lamp is to measure its c. p. in directions making angles of 5·7, 17·5, 30, 44·4, and 64·2 degs. with the horizontal, and taking the mean of the results. The easiest way of drawing these angles is by the graphical construction indicated in Fig. 3. If greater accuracy is required the same thing can be done in several vertical planes passing through the axis of the lamp and the mean of the results taken. —**A. Russell, M.A., M.I.E.E.,** *Proc. I.E.E., Vol. 32, Part 161*, pp. 631–646.

TRACTION.

The Electrification of Steam Railways.

THE writer endeavours to show that for such a service as would make it worth while changing from steam to electricity for haulage, the three-phase system has a slight advantage in first cost and in economy, but not sufficient to compensate for the additional complexity introduced into the train and line equipment, and that, on the whole, the present practice and tendency in America and England will be found to be justified, and future developments for some time to come will follow on the same lines.—**E. Parry,** *Light Rly. and Tram. Jnl., June 5, 1903*, pp. 379, 380.

Monophase Traction.

SERIES MOTORS approach to some degree the elasticity of steam-engines, but for their dissipating, in starting, part of their energy on passive resistances. As these motors should therefore be fed at variable voltages, monophase motors seem to be especially available for electric traction purposes. allowing of high-tension currents being used, and necessitating only one feed-wire in addition to the rails serving as returns. The series monophase motor, designed by the author, works at constant voltage, regulating automatically its speed according to the load, the speed being inversely proportional to the latter for high values of the torque required; it permits of regulation of the voltage being effected without losses and of the speed being varied within very extensive limits. On the other hand, it is not able to use directly high voltages, being moreover for the moment bound to relatively low frequencies. The characteristic curves of the motors, as given in the original paper, seem very advantageous, showing from a comparison between the monophase and continuous-current motors that for speeds of 22 km. per hour the former will require in starting 9·4 watt-hours per ton, against 12·35 watt-hours for the direct-current motor. As regards the energy absorbed during a trial run by the two motors under equal conditions, for mean speeds of 17·5 km. per hour and about 2¼ starts per km., the integration of the kw.-meter diagrams will give for the monophase car (9·45 tons) ·45 watt-hours per ton-km., for the continuous-current car (9·65 tons) 70 watt-hours km. Calculating the power factor from the experimental curves obtained, the value 0·7 was obtained in starting, whereas at the generating station the power factor comprising the line transformer motor is as an average during the run 0·8, varying between 0·6 and 0 95.—**Dr. G. Finzi,** *L'Elettricista, Vol. XII., No. 11, Nov. 1, 1903*, pp. 261–264.—*A. G.*

The Proportions of Modern Locomotives.

THE author has collected and arranged a considerable amount of data in tabular form with the twofold object of showing the tendency of modern American locomotive practice, and also of comparing the dimensions of the locomotives with one another by a simple and logical method. Table I. shows the dimensions for representative locomotives and the ratios which have been calculated for purposes of comparison. The dimensions considered are as follows: weight, cylinder diameter and stroke, driving wheel diameter, boiler pressure, total heating surface and grate area. The maximum cylinder tractive effort has been calculated in each case, the mean effective pressure for the single-expansion engines being taken at 85 per cent. of the boiler pressure; for the four-cylinder compounds at two-thirds of the boiler pressure in the high pressure, and one-quarter of the low-pressure cylinders; and for the two-cylinder compounds the work has been assumed equally divided between the cylinders, the high-pressure working with a mean effective equal to two-thirds of the boiler pressure. The figures enumerated above are given in columns 2 to 9 of the tables, and in columns 10 to 12 are given factors measuring the ratios which the four important dimensions of adhesive weight, tractive effort, heating surface, and grate area bear towards one another. Column 13 gives a factor of steam consumption, and column 14 the total weight of the engine per square foot of heating surface. These five factors give a fairly complete analysis of the proportions of the locomotives, and affords means for a rational comparison of different designs. The first three factors (columns 10, 11, and 12) are based on the four determining dimensions of the locomotive weight on drivers, cylinder tractive effort, heating surface and grate area, measuring, respectively, the ratios of weight on drivers to tractive effort, of tractive effort to heating surface, and of heating surface to grate area. The following simple calculations show the exact relation between the steam consumption factor and the rate of steam combustion: Let V be the speed in miles per hour, T the maximum cylinder tractive effort, P the percentage of maximum tractive effort developed at the speed V, then PT is the tractive power at the speed V. Let h be the amount of water required per horse-power per hour by the cylinders, Q the total amount of water used per hour, S the heating surface in square feet, q the amount of water evaporated per square foot of heating surface per hour; then $q=\frac{Q}{S}$. Let r be the number of revolutions made by the driving wheels per minute at the speed V, D the driving wheel diameter in inches, then $V=\frac{rD}{336}$. Now the horse-power developed is $\frac{PTV}{375}$. Hence the water consumed is $Q\frac{PTVh}{375}$

therefore $\frac{Q}{S} = \frac{p.h}{375} V \frac{T}{S}$. But $\frac{Q}{S} = q$, and $\frac{T}{S}$ is the factor B, hence $q = \frac{p.h}{375} V B$ (1). This establishes the relation between the factor B, the necessary rate of evaporation, the cylinder conditions, and the speed in miles per hour. In a similar manner the other considerations are dealt with, and 22 tables in all are given.—**Lawford H. Fry,** *Rly. Age, Sept., 1903,* p. 404.—*C. S. L.*

Some Notes on Train Resistance.

THE evolution of the modern passenger train has brought about two gradual changes—viz. a great increase in weight, amounting to from 100 to 200 per cent.; a considerable decrease in tractive resistance, amounting to nearly 50 per cent. for equal weights. Trains have been improved both in respect of frictional and atmospheric resistance. The friction is reduced by the following causes: (1) The bogie system is used throughout; (2) oil is employed for lubrication instead of grease. A constant resistance of 8 lbs. per ton, which has been usually adopted in calculations of the resistance of trains running in grease, is likely to be succeeded ultimately by a constant resistance of 4 lbs. or 5 lbs per ton with oil lubrication. But the great source of economy lies in the sub-titution of the principle of the bogie for the sledge-like action of fixed parallel axles; for by this means not only the constant element of resistance but likewise the variable resistance will be materially diminished.—**C. F. Dendy Marshall, B.A.,** *Engineer, Vol. XCVI., No. 2,492,* p. 321.—*C. S. L.*

Piston-Valves in Compound Locomotives.

IN 1898 the Eastern Railway of France adopted some compound four-cylinder coupled locomotives with flat slide-valves. Their working drew attention to three points in particular which seemed capable of improvement—viz. they worked to less advantage at a speed above 250 revolutions per minute than at a lower; the blast was weaker than in non-compound engines, chiefly when the speed was so high that the pressure in the intermediate receiver fell below 28 lbs. or 35 lbs. per sq. in.; and for easy running the cut-off could not be earlier than 60 per cent. of the stroke in the big cylinder, which consequently did more work than the small, and ran down the pressure too low in the intervening receiver. All three defects were traced to the need in a double-expansion engine that the whole of the passages for the steam to flow through should be larger than in a single-expansion. Fitting piston-valves to 20 of the same four-cylinder compound locomotives resulted in a saving of 10 per cent. in coal consumption. The cylinders, but not the cylinder cover, are steam-jacketed. The jackets have worked well, but their efficiency has not yet been determined separately. The author concludes by strongly advocating the use of piston-valves, which, he says, "afford the means of equalising the power in the small and large cylinders without entailing any countervailing disadvantage." Their chief merit lies in enabling compound locomotives to attain a high speed with relatively small wheels, so that express engines with six wheels coupled can now be built, which, with only a moderate length of rigid wheel base, possess great adhesion and ample power, both for starting and for going up inclines with heavy loads.—**L. C. M. Pelletier,** *Prac. Eng., 1903, Vol. XXVIII., No. 865.—C. S. L.*

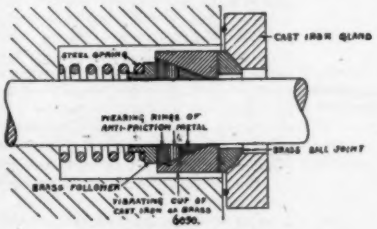
MECHANICAL.

The Making of 18-inch Steel Eye-bars.

WHEN steel eye-bars were first made, it took from eight to ten heats to make a finished head. The greatest difficulties have always been experienced in the forging of the narrow thin bars on account of their buckling vertically in upsetting. As the size of the bars was increased it was found less difficult to upset and forge the heads than with the thinner bars. But a new difficulty was encountered in the full-sized tests of such bars; they frequently broke in the neck, head, or body, showing a granular fracture, small reduction of area and percentage of elongation. The ordinary annealing does not always restore the heavy bars that have been injured in this way, and the tension and bending tests on small specimens will not always show such injury. This trouble with heavy bars became a serious matter, and a large series of bending tests on full-sized bars was made in order to have some good reliable check on the material as it came from the rolls, and before upsetting and forging the bars. The results of these tests were very satisfactory, and it was found that it is necessary to finish them at a lower temperature than formerly. A great many of our specifications contain the following clause: "When material is to be annealed or otherwise treated before use, the specimen representing such material is to be similarly treated before testing." This has done more to prevent progress in the manufacture of eye-bars than anything else. It is an important matter to have sufficient thickness in the wide bar to prevent the head from dishing. To prevent this it is customary to wedge each side of the head in the testing machine. This is one of the objections to the use of eye-bars or links cut from wide thin plates, as is customary in Europe. Another objection is that these plates have always been used in the condition in which they leave the rolls without the beneficial effects of annealing. All that has been said applies equally to carbon steel or to nickel steel. When high tensile strength and elastic limit are required in large bars, steel containing 3½ per cent. of nickel has special advantages, as this amount of nickel replaces about 0·15 per cent. of carbon, and the steel can be worked with greater safety. It gives a higher ratio of elastic limit to ultimate strength, and is a tougher material, giving better stretch and bend. Corresponding advances have been made in the annealing of eye-bars, in the matter of charging the bars in the annealing furnace, carefully observing the annealing temperature, and in the matter of cooling.—**W. R. Webster, M.Am. Soc.M.E.,** *Eng. News, Vol. L., No. 15,* p. 325.

Metallic Packings.

THE purposes of a piston-rod or valve-stem packing are to prevent leakages of steam with minimum pressure and friction. At the same time the packing should be designed so that it will be sufficiently flexible to follow slight lateral movement of the rod while remaining steam-tight. Flexible packings of the latest design do not fill the entire stuffing-box, as steam is allowed to enter the stuffing-box, and the packings thus have a chance freely to acquire a vibratory motion. Steam leakage around the walls of the stuffing-box is taken care of by metal or other gaskets under glands, and by sliding faces ground steam-tight. The segmental block form of flexible packing usually consists of metallic segments of metal held close to the rod by some form of pressure. The principal objection to segmental packings is that they are expensive in manufacture and maintenance. They are generally of complicated nature, and in a triple-expansion engine it is almost impossible to obtain the same length of wear from the packings for the three different cylinders. Flexible packing of the conical-ring type (see Fig.) has given better satisfaction than all others, and is the packing used on 90 per cent. of the locomotives running in the United States. The principle of this packing is that conical, soft-metal rings are pressed against the rod, and packing is accomplished by the rings being forced into a solid cup bored to conform to the outside



METALLIC PACKINGS.

of the rings. With this type of packing nothing comes in contact with the rod except the white-metal rings. The glands, neck bushings, cups, followers, etc., are bored larger than the diameter of the rod, and as the rings are of soft-metal, they cause very little friction and wear on rods.—**C. Longstreth,** *Jnl. Am. Soc. Nav. E., Vol. XV., No. 2,* pp. 404–416.

Diagrams for Estimating Hydraulic Machinery.

IN designing the ram cylinders of hydraulic machines, the load on the ram and the water-pressure to be used are specified. Assuming a pressure of 1,500 lbs. per sq. in., to be used, the two accompanying diagrams give on inspection the main dimensions of cylinder and ram for any given load. Suppose

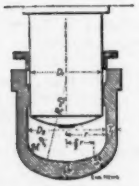


FIG. 1.

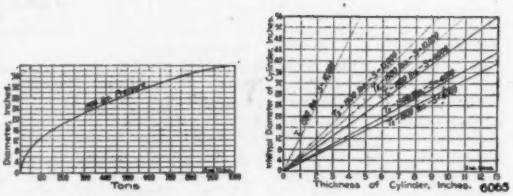


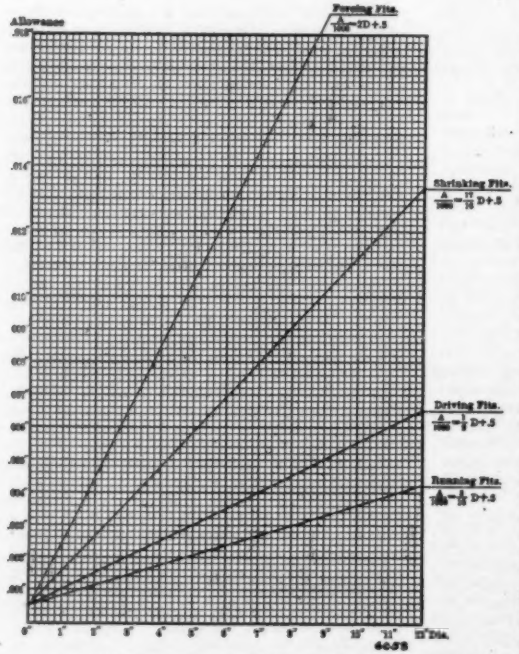
FIG. 2.

DIAGRAMS FOR HYDRAULIC MACHINERY.

we have a cylinder as shown in Fig. 1, required to have a capacity of 450 tons. In diagram 1, Fig 2, find 450 tons on the horizontal axis, and the ordinate to the curve at this point gives the required diameter of cylinder, in this case a little less than 28 ins. Before deciding on the diameter of the ram, it must be remembered that usually either a counterweight or an opposing hydraulic cylinder is used for the return stroke, and the ram must be made sufficiently larger to allow for the power consumed here. The internal diameter of the cylinder D_2 in Fig. 1, is made 1 to 2 ins. larger than the diameter of the ram, depending on the size of the ram. This would make D_2 in our example about 30 ins. The three thicknesses of the metal in the shell, T_1, T_2, T_3, Fig. 1, may be determined from diagram 2, Fig. 2, for either cast-iron at a safe fibre stress of 4,000 lbs., or cast-steel at 10,000 lbs. per sq. in. In diagram 2, the full lines are for cast-iron, the dotted lines for cast-steel. If in our example the internal diameter of the cylinder is 30 ins., and the cylinder is to be made of cast-steel, we read from diagram 2 that the required thickness of the side walls, T_1 is $2\frac{1}{2}$ ins., T_2 is $5\frac{1}{8}$ ins., and T_3 is $4\frac{1}{4}$ ins. We can then sketch out the cylinder to scale and estimate its weight and cost. Thus if we take a cast-iron cylinder 36 ins. in diameter, we find from diagram 2, Fig. 2, that the thickness of the metal at the bottom should be 12 ins. This excessive weight makes it inadvisable to use cast-iron for cylinders of this size. The steel cylinder under the same conditions would be 7 ins. thick on the bottom, and 3 ins. thick in the side walls.—**Frank B. Kleinhaus,** *Eng. News, Vol. L., No. 17,* pp. 362–3.

THIS paper explains the deduction of formulæ and curves. Data were plotted and empirical formulas were deduced for various fits. The Fig. shows representative curves and the formulæ for each. Forcing fits may be defined as those which require the use of some form of press, to complete the assembling operation. The allowance should never be so great as to prevent the stress from coming well within the elastic limit or the crushing strength of the materials employed. The best results are obtained when both surfaces are ground to fit gauges. The representative curve chosen for shrinking fits was one whose equation gave allowances which agreed with the standard adopted by the American Railway Master Mechanics' Association for locomotive wheel-centre and tyre gauges. The allowances obtained by the use of this formula, while not excessive, are sufficient to insure a tight fit, thus avoiding the danger of excessive shrinkage stresses. Very few data could be secured for driving fits, the inference being that this method is about obsolete, and the practice of driving home a plug by blows is too crude to be used except where no other method is available. A running fit is designed to allow the surfaces in contact to move or revolve freely over each other. The more nearly the surfaces in contact approach perfection, the better will be the fit. It will be remembered, of course, that in order to obtain the bore diameter the allowance should be added to the diameter of the shaft, which the author was able to procure.—**S. H. Moore,** *Trans. Am. Soc. M.E., Vol. XXIV., No. 978.*

Forcing, Shrinking, Driving, and Running Fits.



REPRESENTATIVE CURVES FOR THE VARIOUS FITS.

WORKS MANAGEMENT.

THE particular drafting room of the Westinghouse works in which the author is interested is turning out drawings at the rate of 20,000 a year, and a constant effort is being made to get things down to a manufacturing basis. Having brought the work of the tracers under control, we turned our attention to the designers, draftsmen and clerks. This resulted in the formation of a separate department called the Standard Division, for keeping the drafting room posted on Westinghouse practice, preparing forms for the transaction of business, the designing of standard parts of machines, the investigation of standard methods of figuring, and the up-to-date posting of draftsmen regarding stock sizes. The first thing taken up by the department was the matter of nomenclature, which resulted in a book of element charts and an illustrated index. We also took up the naming of small pieces, and also much used parts of machines. The result of this was an illustrated index, of which every draftsman has a copy. In modern drafting rooms, whether large or small, draftsmen should be kept thoroughly posted as to the sizes of standard parts kept in stock in the shop store rooms. In the Westinghouse drafting room there is a large swing-leaf poster, upon which stock bulletins are secured, containing up-to-date information regarding sizes of materials kept in stock in the shop store rooms. Information regarding existing patterns, dies and tools, etc., is carried in card indexes. In the Westinghouse drafting room permanent instructions are issued as circular letters: the complete book of them at the present time is a volume about 400 pages of typewritten matter, the whole being duplicated six times. There is a printed book in which the instructions are classified, and in which the substance of each letter has been "boiled down" into a few words. Every drawing after being checked is handed to the inspector, whose duty it is to catch all deviations from standard, and under whose advice all records are made of such patterns and much used pieces as draftsmen may wish to refer to in the future. In general, information to draftsmen belongs to one of two classes: standard or special. Under standard information, we have the Drawing Dictionary, Element Charts, Illustrated Index,

Mechanical Drawing in the Modern Drafting Room.

Circular Letter Digest, Example Drawings and Abbreviations. Under special information are included records that have to be kept up-to-date.—**G. H. Follows,** *Eng. Soc. West Pa., Vol. XIX., No. 6,* pp. 336-359.

Foundry Accounting.

COST of product is invariably composed of three elements—labour, material, and indirect expenses. It is generally admitted that the last element offers the greatest opportunities for cost reduction. The price of labour is largely governed by local conditions, that of material by ruling market prices; whereas the amount of manufacturing expenses is very largely a question of efficient or non-efficient management. Accepting these statements, it follows that opportunity for cost reduction is in direct ratio to the proportion that indirect expenses bear to the cost of the product. Assuming a foundry and a factory making machine tools, the labour and material directly chargeable to individual costs will represent a larger proportion of the cost in the latter case than in the former. On the other hand, the indirect manufacturing expenses of the founder will be larger in proportion to the cost of his output than those of the machine-tool builder. The logical inference is that, efficiency being equal, a cost system in the foundry offers more opportunity for cost reduction than in the machine shop. In its relation to estimating, the word "costs" must be taken in its broadest sense. Accurate and reliable records of the cost of operating and of maintenance as well as costs of production are essential to the close estimating required by modern conditions.—**Kenneth Falconer,** *Jnl. Amern. Foundrymen's Assn., Vol. XII., No. 2,* pp. 258-264. —*P. L.*

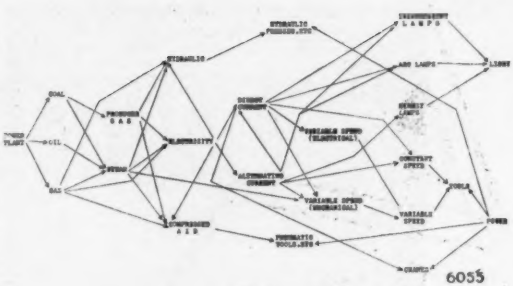


FIG. 1.

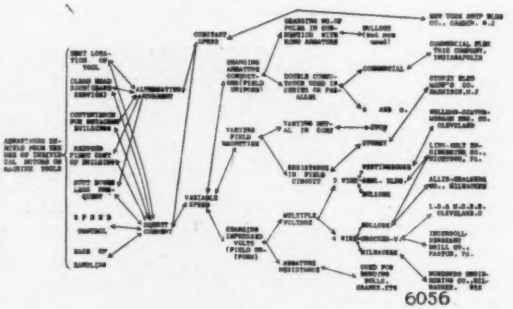


FIG. 2.

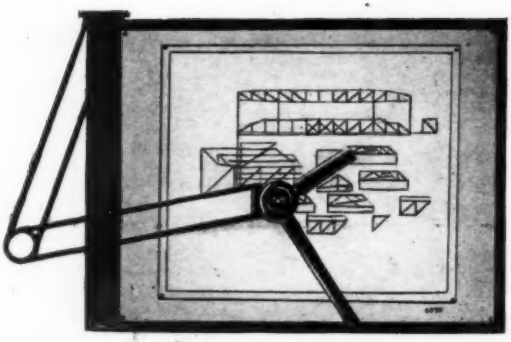
MACHINE SHOP PROBLEM.

The Machine Shop Problem.

BUILDINGS are commonly designed and erected without proper consideration of the work in view. The architect cannot lay out to advantage buildings for a given plant unless conversant with the character of the work. The location of the machines, the system of power transmission, and innumerable other details, materially affect the design of buildings, but manufacturers continue to design and erect their buildings independently of the equipment or of the work in view. While this paper is devoted to the machine shop in particular, a general subdivision of the departments of a given establishment is contained in a chart showing the position occupied by the machine shop in the general scheme. Another chart subdivides the production department into the buildings, equipment, etc., each of these details being further analysed. When deciding upon the types of machines desirable, it is necessary to consider the question of "power application." Fig. 1 indicates approximately the number of courses which may be open for fulfilling the conditions in view. Either coal, oil, or gas may be used, according to the location and size of plant, and so the desirability of each of the alternatives will be governed by special conditions. The possible advantages resulting from the use of individual motors and the various types of apparatus manufactured for this work, are graphically shown in Fig. 2. The names of concerns who have installed the different systems are given to the right. While all the charts given are only of value in so far as they present to the mind a picture which can be readily comprehended, we can at times graphically distribute costs, etc., showing the cost value of the different operations. **C. Day,** *Trans. Am. Soc. Mech. Eng., Vol. XXIV., No. 0999.*

Drawing Office Equipment.

THE Universal Drafting Machine, invented by Mr. Chas. H. Little, is the most radical departure which has been made in the drafting line, and is a very important aid to the draftsman. This machine is doing all that was promised for it by the inventor, and something more. The illustration shows one of these machines



DRAWING-OFFICE EQUIPMENT.

in use for working out strains graphically. The machine is based on two fundamental ideas—one, that all angular work must be as readily put in as straight work ; and two, that we must enable the draftsman to draw and scale a line with the same edge at the same time. This applies in straight work as well as in angular work, and eliminates considerable erasing, as well as the constant changing from one tool to another. In short, work that formerly required two tools to be used on each line now requires only one, saving the time necessary to change from one tool to another. The protractor used with this machine also has a new feature, in that it is provided with spring tops for the angles most frequently used, and at the same time it may be clamped to any angle. In actual tests, Mr. Little has demonstrated on both a typical mechanical and a typical structural drawing that the saving of time is very nearly the same, and amounted to 33⅓ per cent.—**J. McGeorge,** *Trans. Am. Soc. Mech. Eng., Vol. XXIV., 1903.*

WATER AND SANITARY.

Raising Water by Compressed Air.

HAVING to provide pumping plant for a boring 15½ ins. diameter and 400 ft. deep, situated in an isolated and somewhat inaccessible position, the author made a careful estimate of the comparative cost of pumping and maintenance with—(1) air-lift, (2) steam-engine, and (3) oil-engine. The results are shown in the following statement, the lift being assumed as 100 ft., and the working hours 3,000 per annum :—

1.—Compressed Air Plant.

	Per 1,000 gals.
Capital charges, labour, and repairs	1·16d.
Fuel as per test October 7, 1902 ...	1·073d.
Total	2·233d.

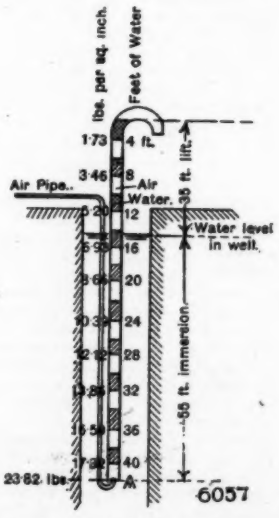
2.—Steam-engine and Borehole Pump.

Capital charges, labour, and repairs	2·4d.
Fuel (average of tests by the author)	0·5d.
Total	2·9d.

3.—Oil-engine and Borehole Pump.

	Per 1,000 gals.
Capital charges, labour, and repairs	1·53d.
Crude oil fuel	0·25d.
Total ...	1·78d.

The most suitable conditions under which the air-lift system (see Fig.) may be applied, are those which exist where a boring is in an isolated and inaccessible position and the air-compressing plant can be placed on an existing pumping station, involving but little outlay in the erection of new foundations or buildings, or in the purchase of additional land, and without incurring the provision of additional labour at the site of the boring. To secure satisfactory results, however, it is important that the difference between the *rest* level and the *pumping* level should not be excessive, that the fluctuations of the same should be ascertained beforehand, and that the ratio between the immersion of the air-pipe and the total lift of the water should be adjusted to the most suitable proportions, and not greatly varied in ordinary working. Although it cannot be denied that the cost of fuel involved by the air-lift exceeds that required with a steam or oil-driven pump of the ordinary form, yet the author believes that, under suitable conditions, the former will prove to be preferable, taking all charges into account in each case.—**W. H. Maxwell,** *Proc. Brit. Assoc. Waterworks Eng., 1903.*



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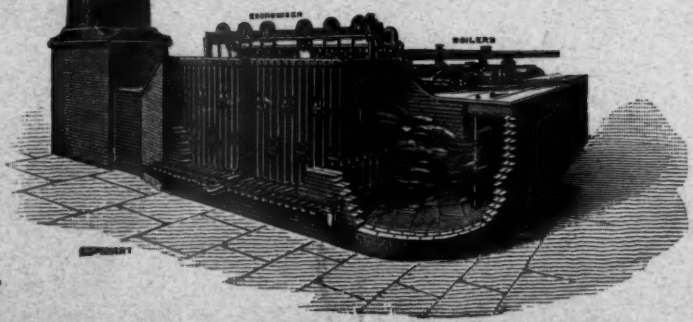

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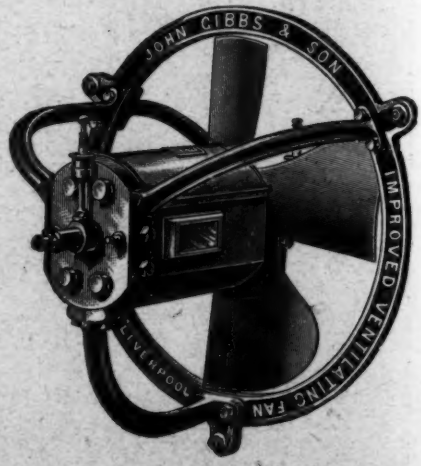

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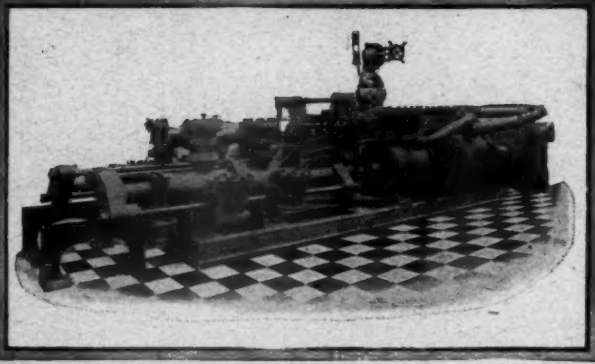

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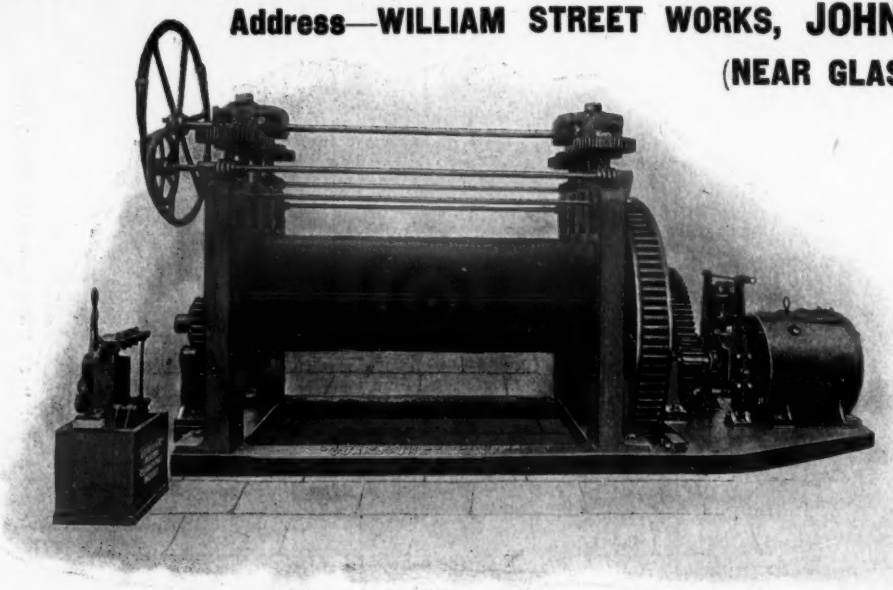

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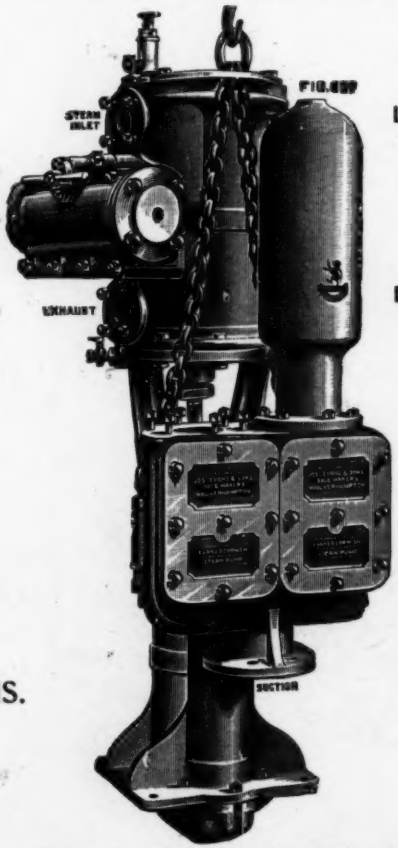

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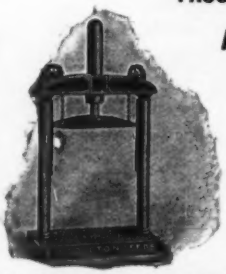

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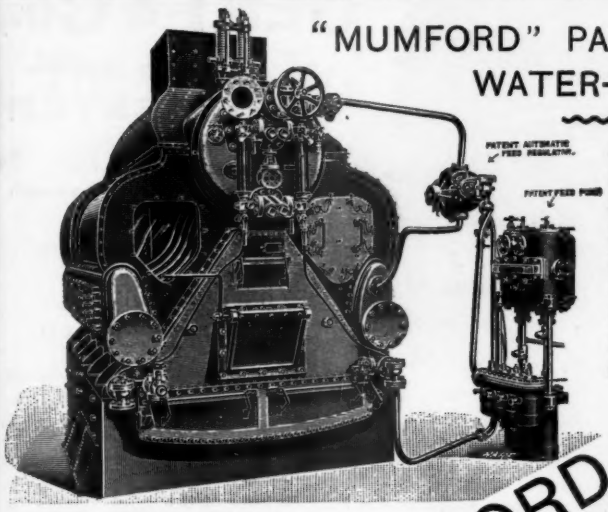

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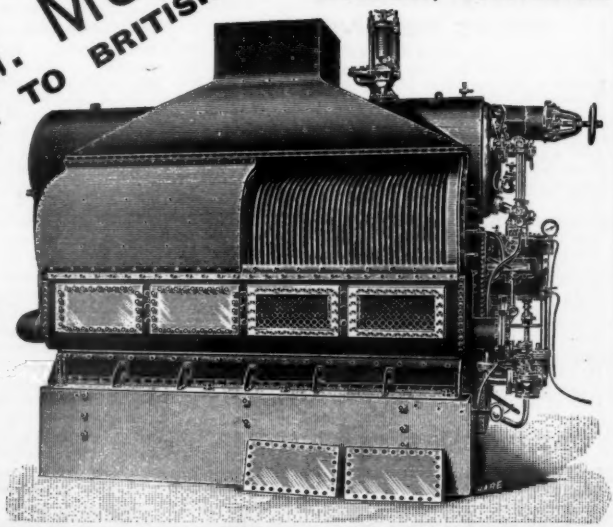

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BOOKS RECEIVED.

THE ENGINEER IN SOUTH AFRICA. A review of the industrial situation in South Africa after the war, and a forecast of the possibilities of the country. By Stafford Ransome, M.Inst.C.E. Westminster: Archibald Constable & Co., Ltd., 2, Whitehall Gardens. 1903. Price *7s. 6d.*

INTRODUCTION TO METALLURGICAL CHEMISTRY FOR TECHNICAL STUDENTS. By J. H. Stansbie, B.Sc. (Lond.), F.I.C. Bristol: John Wright & Co.: London: Simkin, Marshall, Hamilton, Kent & Co., Ltd. 1903. Price *4s. 6d.* net.

JAHRBUCH FUR DAS EISENHÜTTENWESEN. By Otto Vogel. Dusseldorf: Kommissionsverlag von A. Bagel. 1903. 10 marks.

SUBJECT MATTER INDEX OF MINING, MECHANICAL, AND METALLURGICAL LITERATURE FOR THE YEAR 1900. Edited by the Secretary, M. Walter Brown. Newcastle-upon-Tyne: Published by the Institute. 1902. Price *£2 2s.*

ANDERSON'S DISTANCE TABLES BETWEEN PORTS IN ALL PARTS OF THE WORLD. North Shields: Wilson & Gillie. New York: Michael Rupp & Co. 1903. Price *3s. 6d.*

CATALOGUES RECEIVED.

TWENTY-FIVE YEAR'S PROGRESS IN FINAL AND SANITARY REFUSE DISPOSAL. By W. Francis Goodrich. 1903. Section G.: "Engineering." Issued by the British Association for the Advancement of Science, Southport Congress, September, 1903. This pamphlet sketches in full the progress made during the past twenty-five years in the final and sanitary disposal of civic waste. It has been generally conceded for a long time past that the only system of disposal which is at once final and sanitary, is that of disposal by fire. Other methods have been tried, such as tipping on land, tipping at sea, sorting and utilisation, and in America a process of garbage reduction, but it may be fairly said that real progress has only been made with one system—disposal by the agency of fire. A quarter of a century ago destructors had been adopted in two towns only: one at the Water Street depôt of the Manchester Corporation, and the other at Beckett Street, Leeds. Both these are still in use. The remarkable evolution from low-temperature to high-temperature working alone has made the refuse destructor possible. To compare the recorded temperature with the old "Behive" Destructor at Nelson, in 1887, with the temperature now obtained by a modern destructor in that town, is to at once appreciate the progress which has been made. To-day, at Nelson, a considerable amount of power is available for electric lighting and traction—in fact, some 40 Board of Trade Electrical Units are generated from each ton of refuse destroyed. Every attempt to secure and maintain a high combustion temperature has at the same time clearly demonstrated the value of the destructor as a power producer, and it has been established beyond all question, that as the destructor is perfected for the performance of its primary duty, so does it become more satisfactory in the performance of its secondary duty—the production of power. It is now generally admitted that one ton of average refuse is capable of generating a similar quantity of high-pressure steam. No less than 63 towns have adopted destructors in combination with electricity works. To-day 1,650 destructor cells are either in operation, or in course of erection in 180 towns in Great Britain, together with no less than 300 steam boilers, as against 12 destructor cells 25 years ago. Large British destructors have also been erected in Australia and New Zealand.

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CATALOGUES RECEIVED.

(*Continued from page 16.*)

THE INTERNATIONAL ELECTRICAL ENGINEERING CO., Clun House, Surrey Street, Strand. Bulletin No. 18, giving detailed description and illustrations of this company's "Universal" Electric Crab. This crab is primarily designed as being suitable for small works, and can be adapted to all existing hand cranes without any alterations being necessary. It is constructed on the lines of a crab for a modern travelling crane, and embodies all the principal points of same. The crab is constructed in three types, *i.e.* for 1·25, 2·5, and 6 h.p. Each of these types is constructed for different loads, from 1 to 12·5 tons.

THE CONSOLIDATED PNEUMATIC TOOL CO., LTD., Palace Chambers, 9, Bridge Street, Westminster. We have received from this firm special circulars Nos. 2, 3, 4, and 5. No. 2, illustrating and describing at length their air compressors and hoists for all requirements. No. 3, illustrating and describing the Chicago Rock Drill, of which they are the manufacturers, and for which they claim that it is very economical in operation, consuming only 42 cub. ft. of free air per min. Its mechanism is very simple, and its entire weight is 50 lbs. Demonstrations have proven conclusively that it performs the work in one-twentieth of the time required by hand. No. 4, demonstrates their "Tynan" Patent Heater and Annealer, its portable features, few connections, and lightness rendering its application general in performing work of an almost inaccessible character, and making it indispensable for a great variety of work in shipyards, shops, etc.

THE HORSFALL DESTRUCTOR CO., LTD., Leeds. A brochure by Monsieur J. Leurs, Head of the Public Works Department of the city of Brussels, entitled "La Nouvelle Usine d'Incineration des Immondices de la ville de Bruxelles." This booklet contains a description of the new Horsfall Destructor erected in Brussels, and recently set to work, together with some particulars of the reasons for which this plant was adopted in preference to any other, and a description of the auxiliary equipment which has been laid down by the city authorities.

THE CAMBRIDGE SCIENTIFIC INSTRUMENT CO., LTD., Cambridge. An illustrated catalogue of this firm's Duddell Patent Oscillographs, of which they are the sole makers. Also of callenderos apparatus for measuring the mechanical equivalent of heat.

BEANLAND, PERKIN & CO., School Close Works, Leeds. List of a new double hack saw to be put on the market, for which it is claimed that the time required for cutting off girders, etc., is reduced by one-half.

NOTICES.

MESSRS. ROYCE, LTD., of Hulme, Manchester, have now completed and started up the new works they have erected at Trafford Park, Manchester, for the manufacture in quantity of dynamos and motors. The works cover a large area, and include a fully-equipped iron foundry, are electrically driven throughout, and have been expressly designed with a view to promoting rapid and economical production. They are equipped with the latest automatic and other machine tools and labour-saving devices, the resultant economy in the manufacture of their standard lines of machines having been such as to enable them to reduce their prices, and thus meet the very keen competition prevailing.

WE regret to announce the death of Mr. George Alexander Dick, the chairman and managing director of The Delta Metal Co., Ltd., of 110, Cannon Street, London.

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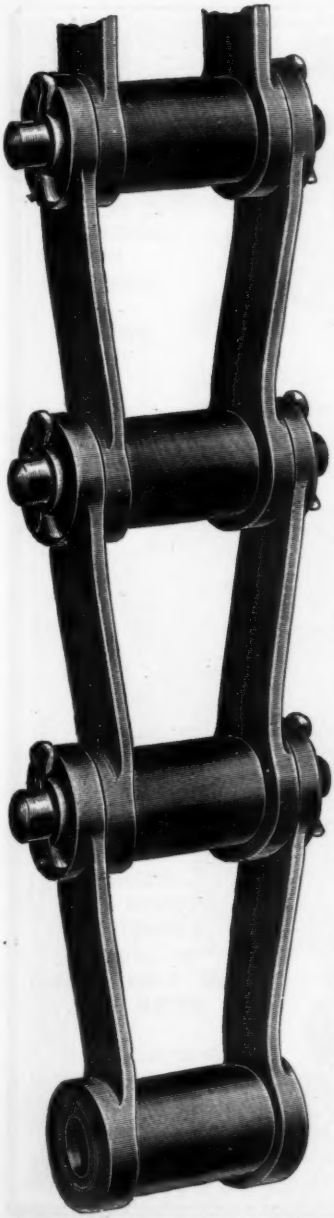
WE understand that the business of the British Westinghouse Electric and Manufacturing Co., Ltd., in the Birmingham neighbourhood, has necessitated the establishment of a new district office situated at Central House, New Street, Birmingham. This new branch is under the management of Mr. G. K. Chambers, formerly contract manager of the British Insulated Wire Co.



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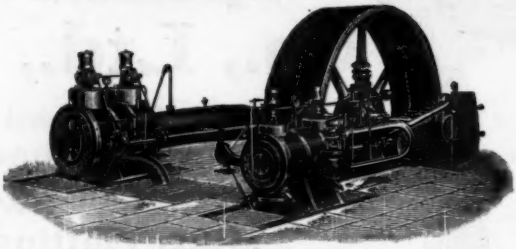

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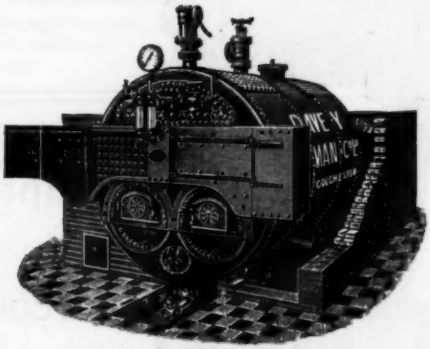

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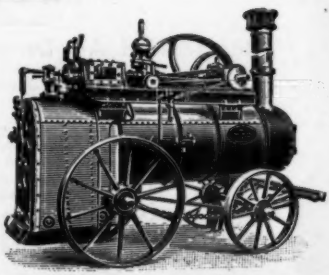

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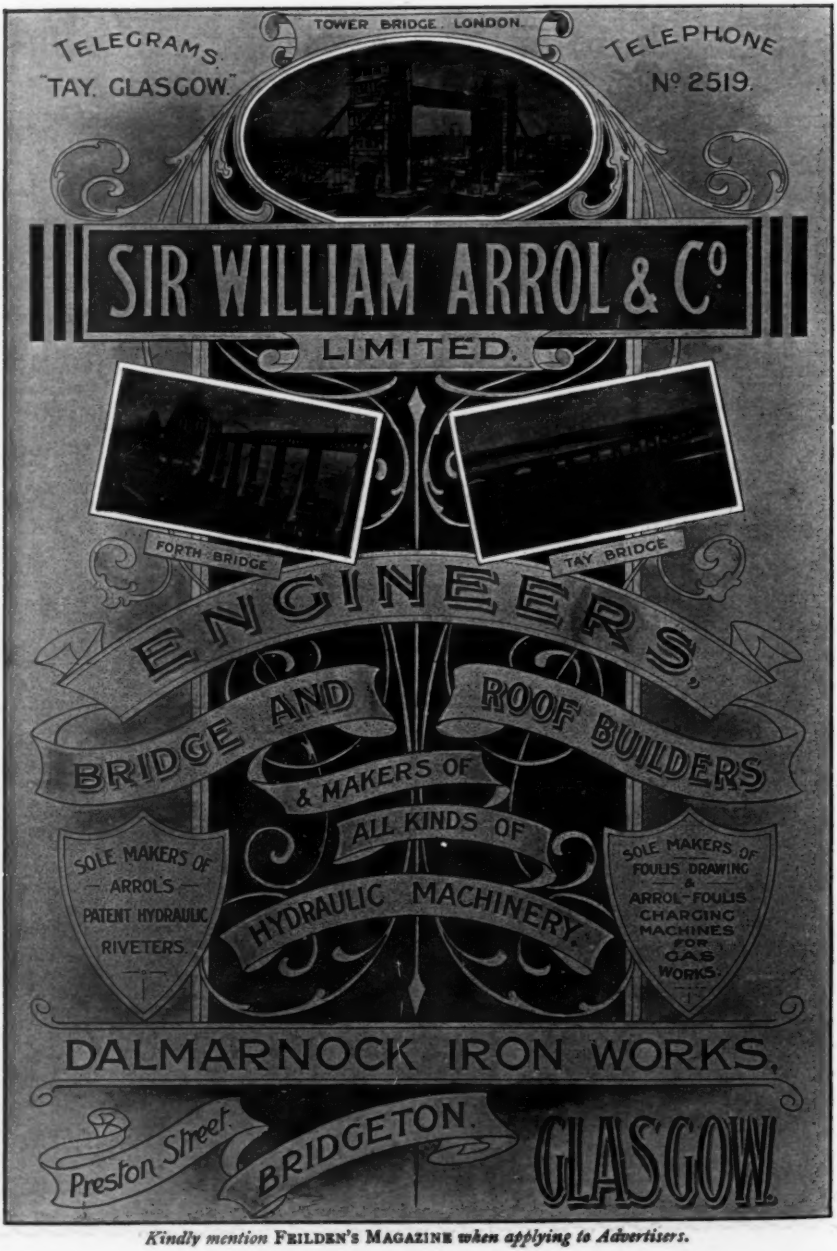

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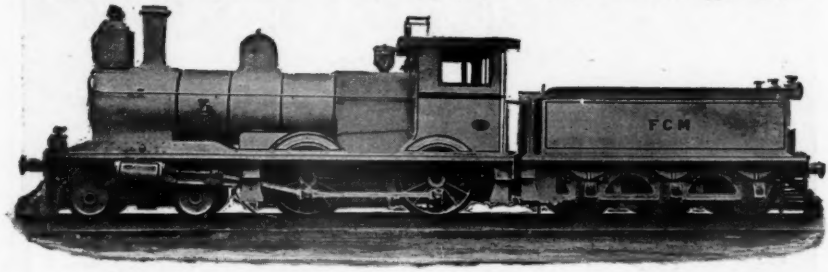

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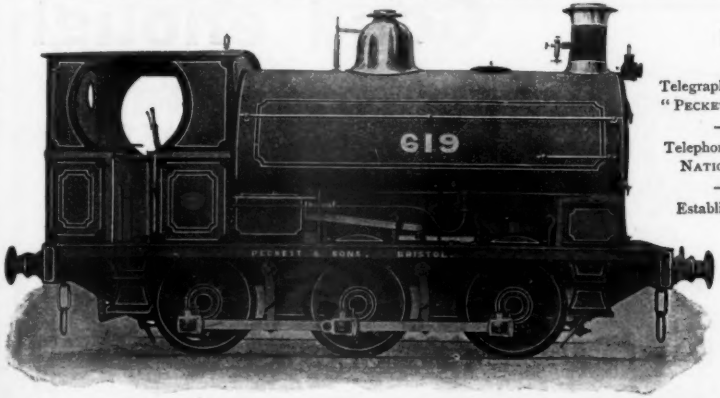

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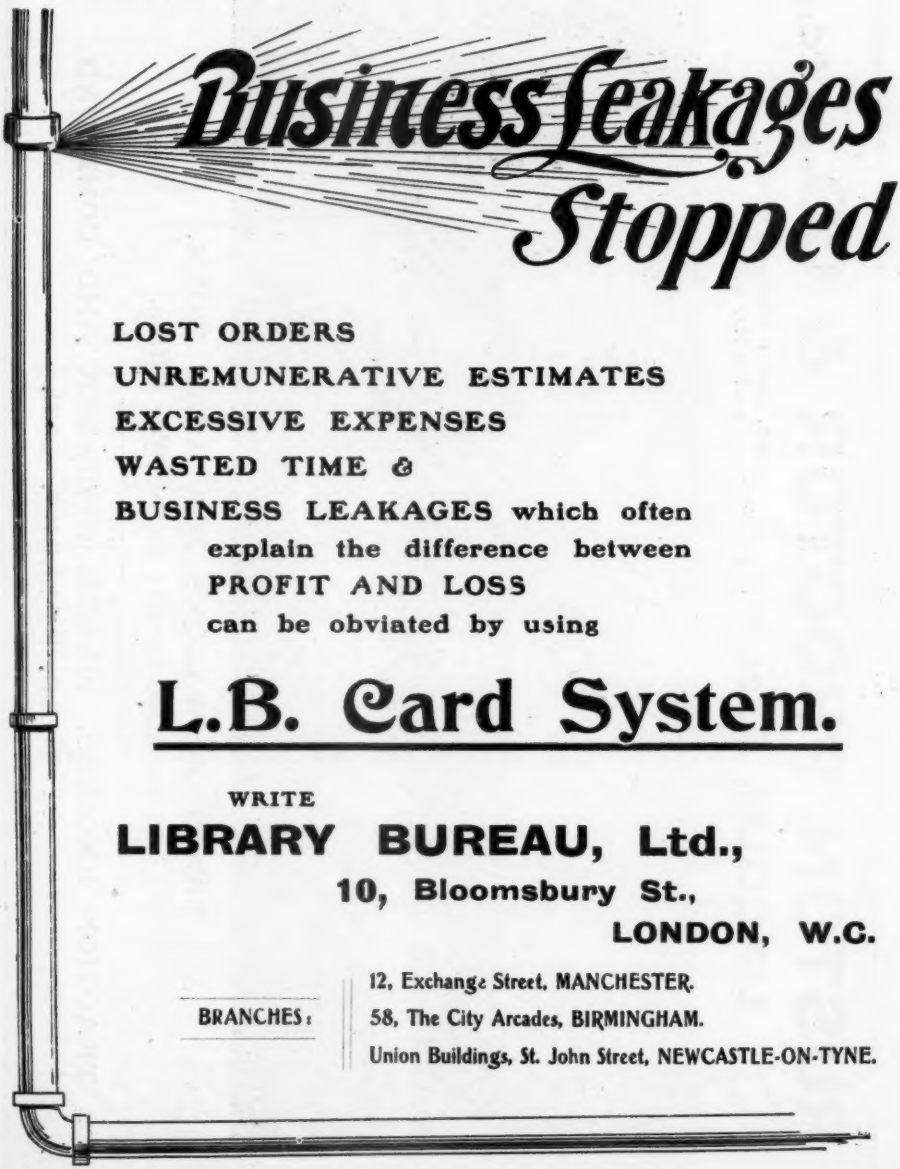

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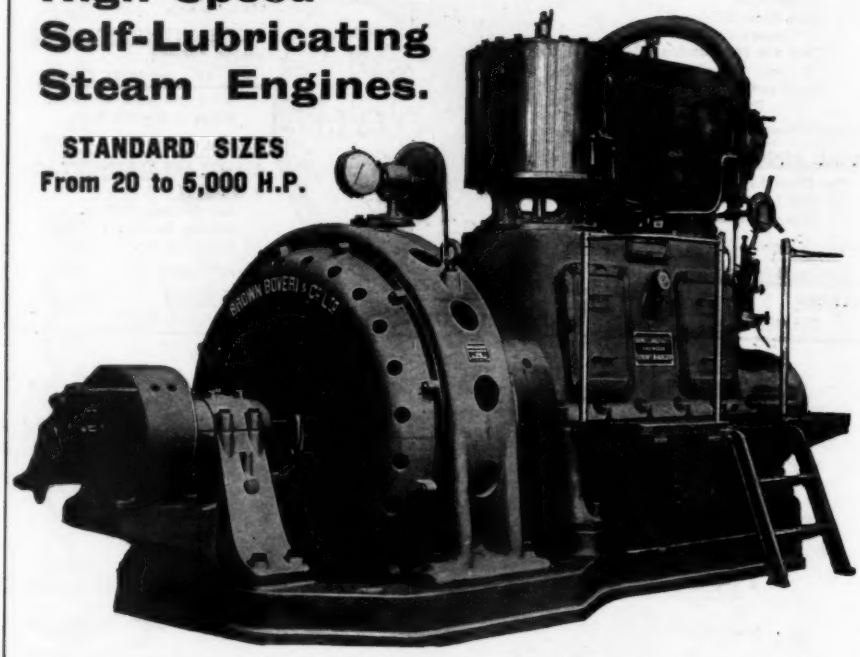

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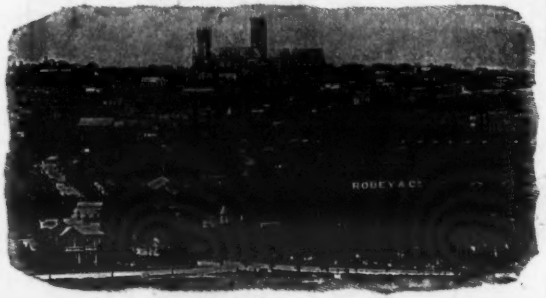

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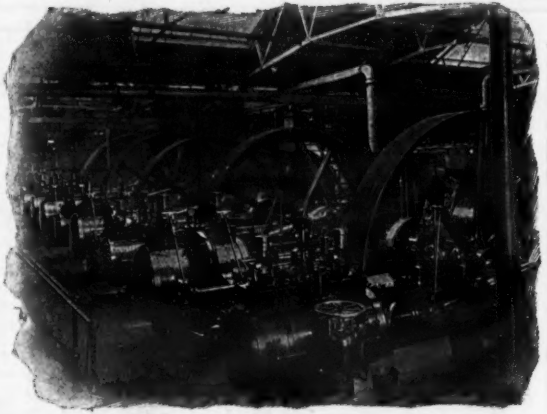

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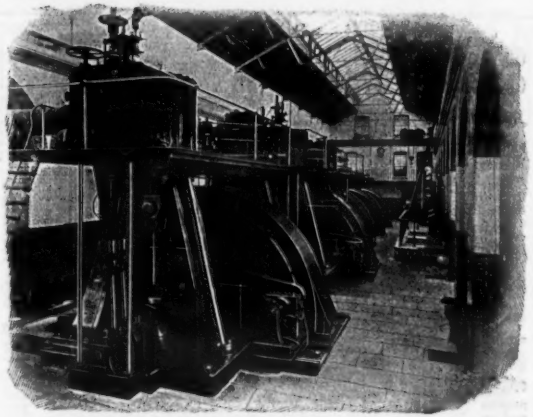

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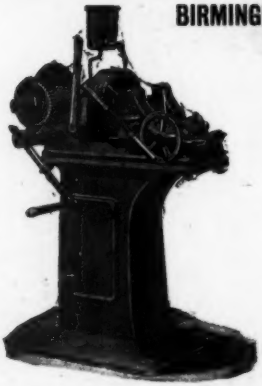

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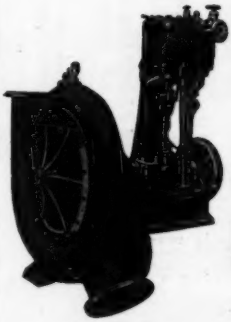

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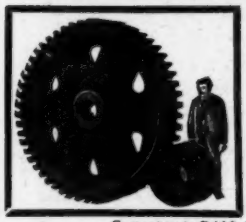

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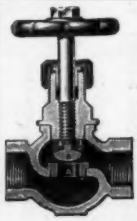

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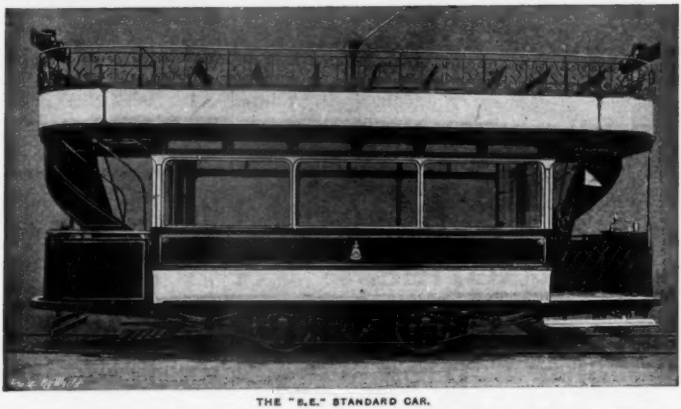

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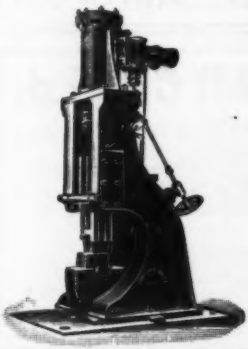

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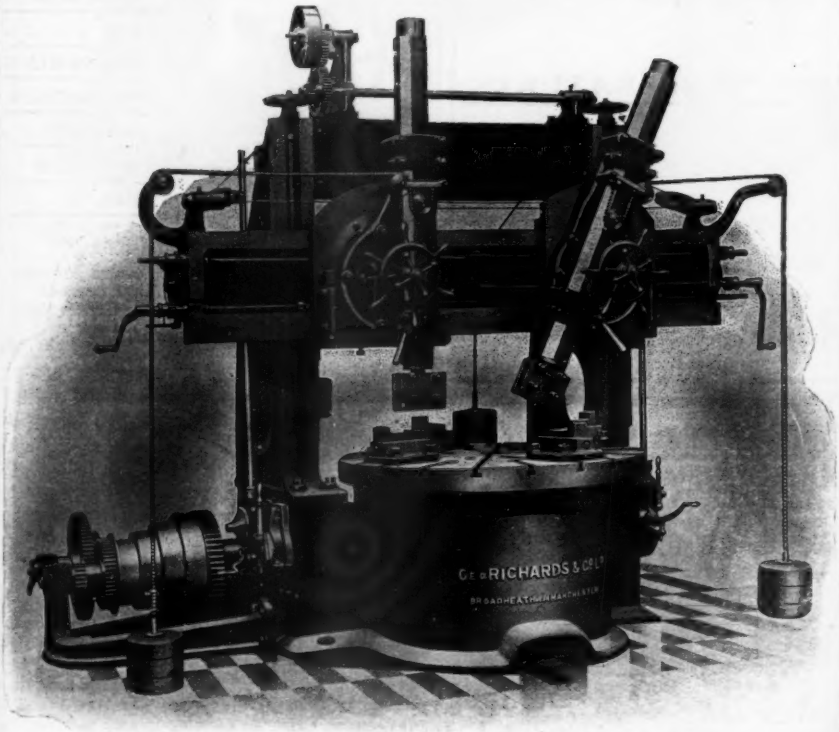

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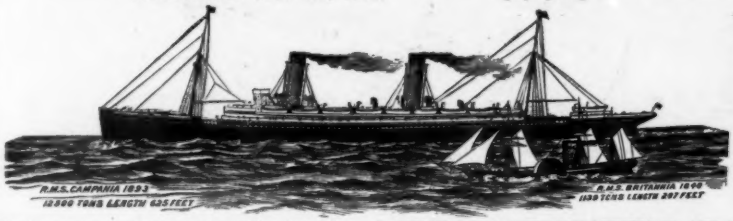

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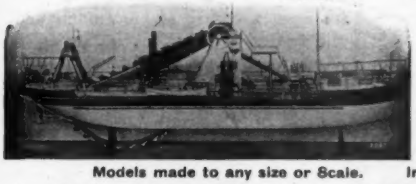

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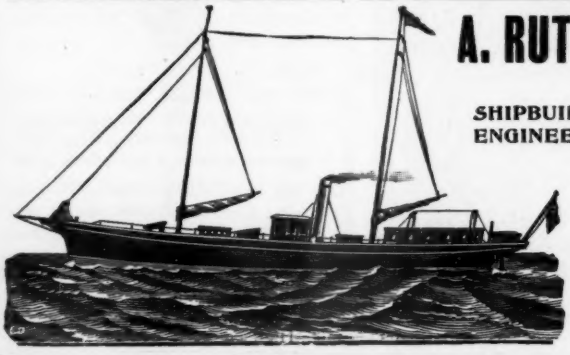

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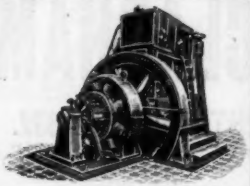

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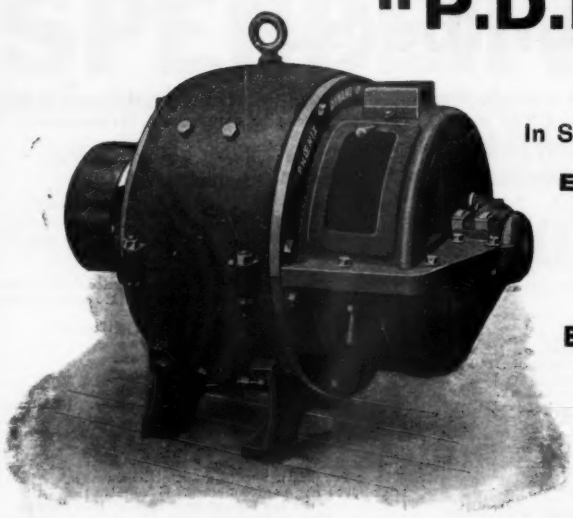

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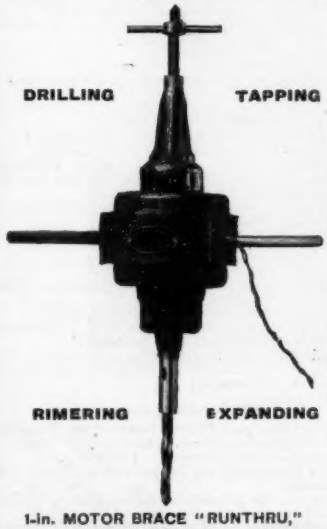

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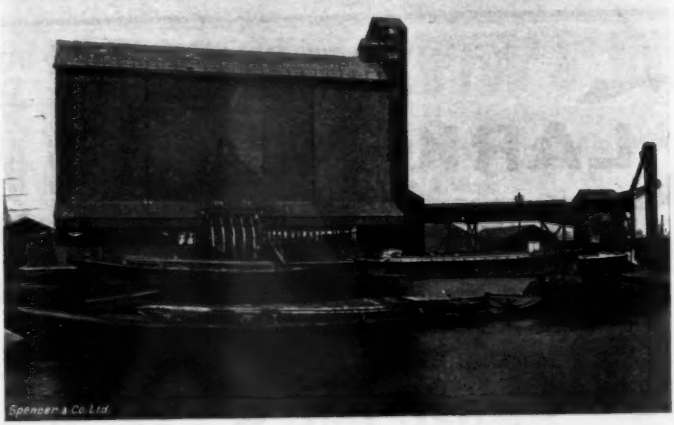

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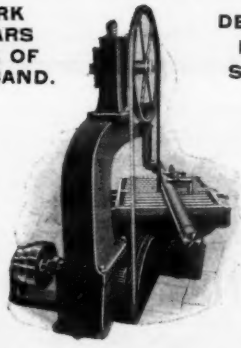

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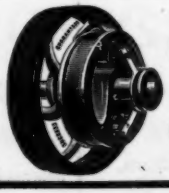

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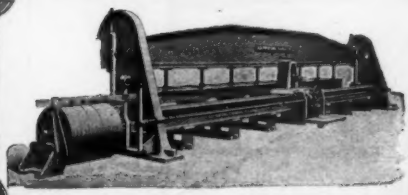

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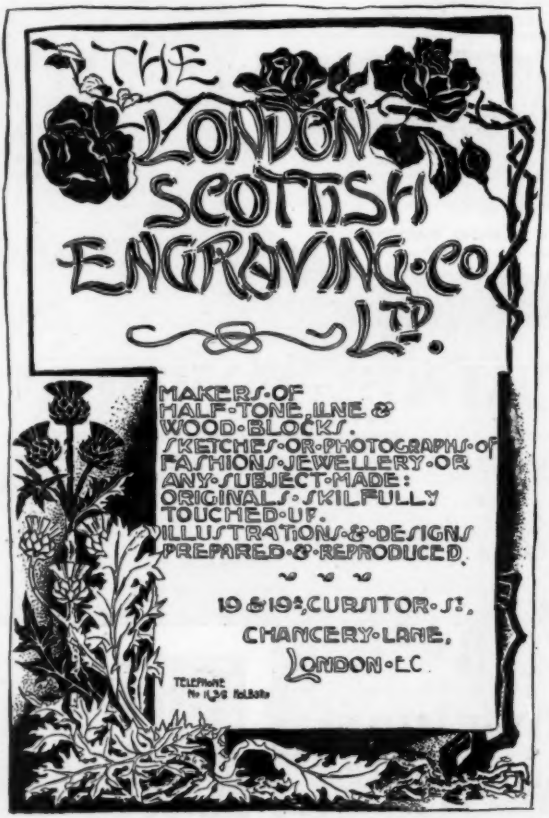
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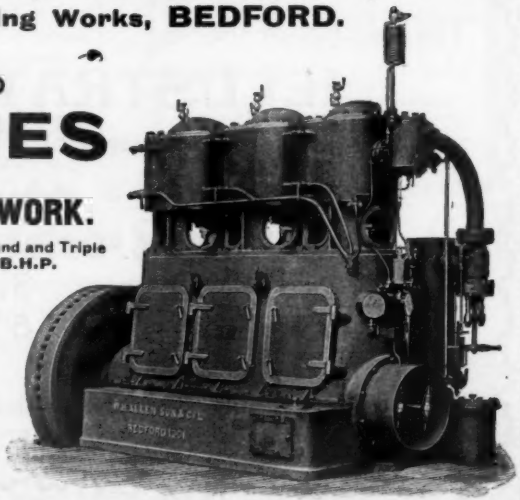

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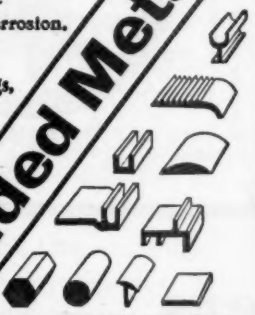

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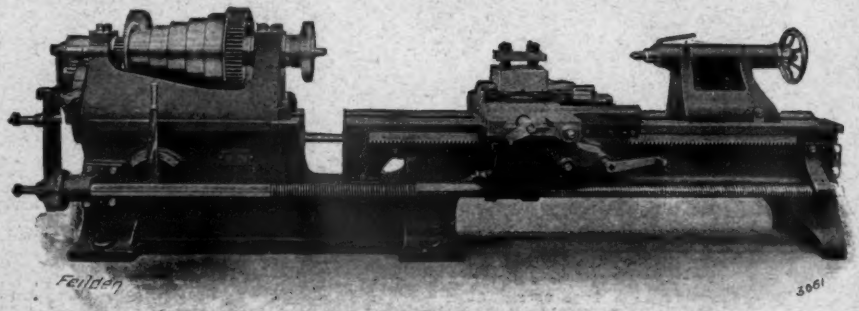

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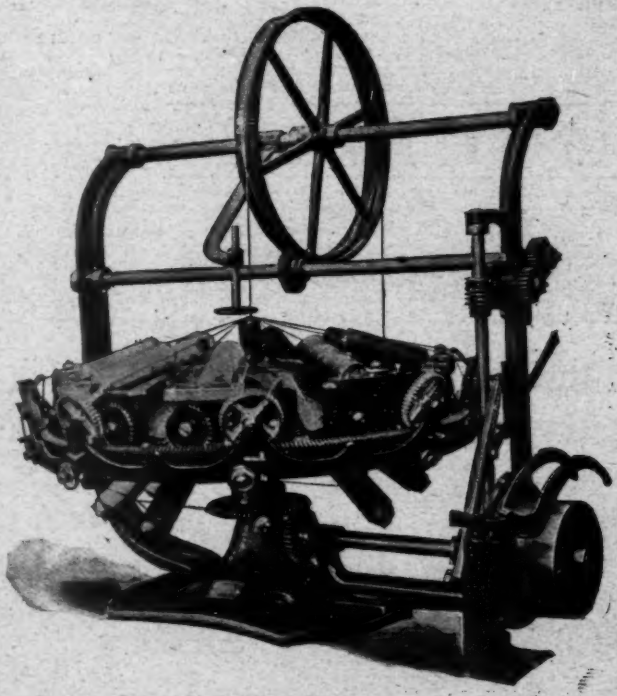

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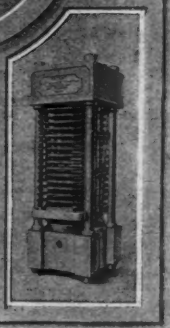

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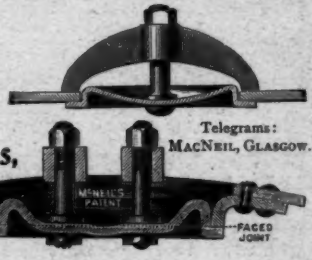

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